The Geological Architecture of Southern Africa

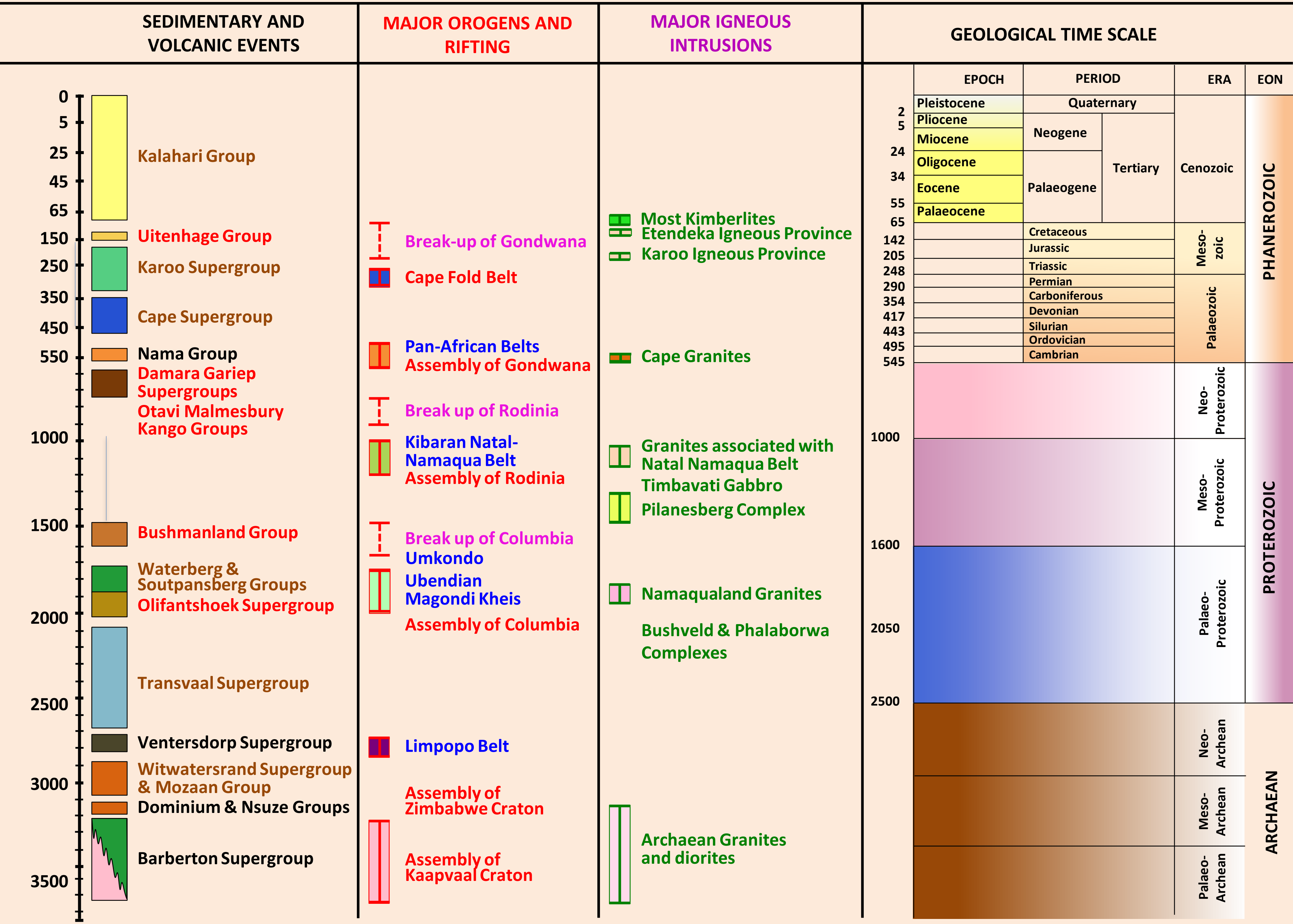

SEDIMENTARY AND VOLCANIC EVENTS
MAJOR OROGENS AND RIFTING
MAJOR IGNEOUS INTRUSIONS
GEOLOGICAL TIME SCALE
0
5
25
45
65
150
250
350
450
550
1000
1500
2000
2500
3000
3500
Kalahari Group
Uitenhage Group
Karoo Supergroup
Cape Supergroup
Nama Group
Damara Gariep Supergroups
Otavi Malmesbury Kango Groups
Bushmanland Group
Waterberg & Soutpansberg Groups
Olifantshoek Supergroup
Transvaal Supergroup
Ventersdorp Supergroup
Witwatersrand Supergroup & Mozaan Group
Dominium & Nsuze Groups
Barberton Supergroup
Break-up of Gondwana
Cape Fold Belt
Pan-African Belts
Assembly of Gondwana
Break up of Rodinia
Kibaran Natal-Namaqua Belt
Assembly of Rodinia
Break up of Columbia
Umkondo
Ubendian
Magondi Kheis
Assembly of Columbia
Limpopo Belt
Assembly of Zimbabwe Craton
Assembly of Kaapvaal Craton
Most Kimberlites
Etendeka Igneous Province
Karoo Igneous Province
Cape Granites
Granites associated with Natal Namaqua Belt
Timbavati Gabbro
Pilanesberg Complex
Namaqualand Granites
Bushveld & Phalaborwa Complexes
Archaean Granites and diorites
EPOCH
PERIOD
ERA
EON
2
5
24
34
55
65
142
205
248
290
354
417
443
495
545
1000
1600
2050
2500
Pleistocene
Pliocene
Miocene
Oligocene
Eocene
Palaeocene
Quaternary
Neogene
Palaeogene
Tertiary
Cenozoic
Cretaceous
Jurassic
Triassic
Permian
Carboniferous
Devonian
Silurian
Ordovician
Cambrian
Meso-zoic
Palaeozoic
PHANEROZOIC
Neo-Proterozoic
Meso-Proterozoic
Palaeo-Proterozoic
PROTEROZOIC
Neo-Archean
Meso-Archean
Palaeo-Archean
ARCHAEAN

PLATE TECTONICS

Plate tectonics fore- and back-arc basins

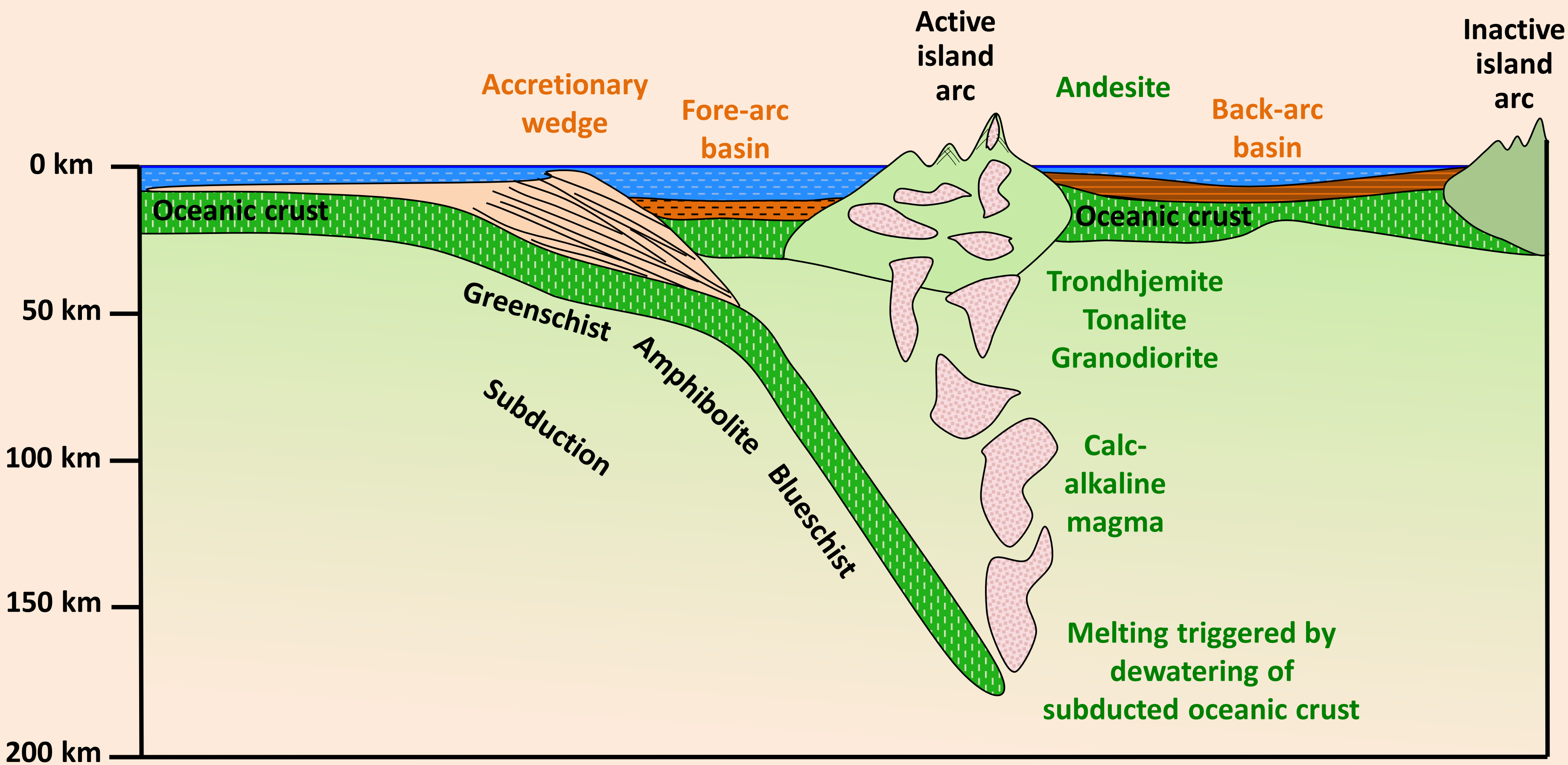


Plate tectonics

Accumulation of all products of spreading and convergence piled into the collisional orogenic belt and the two continents

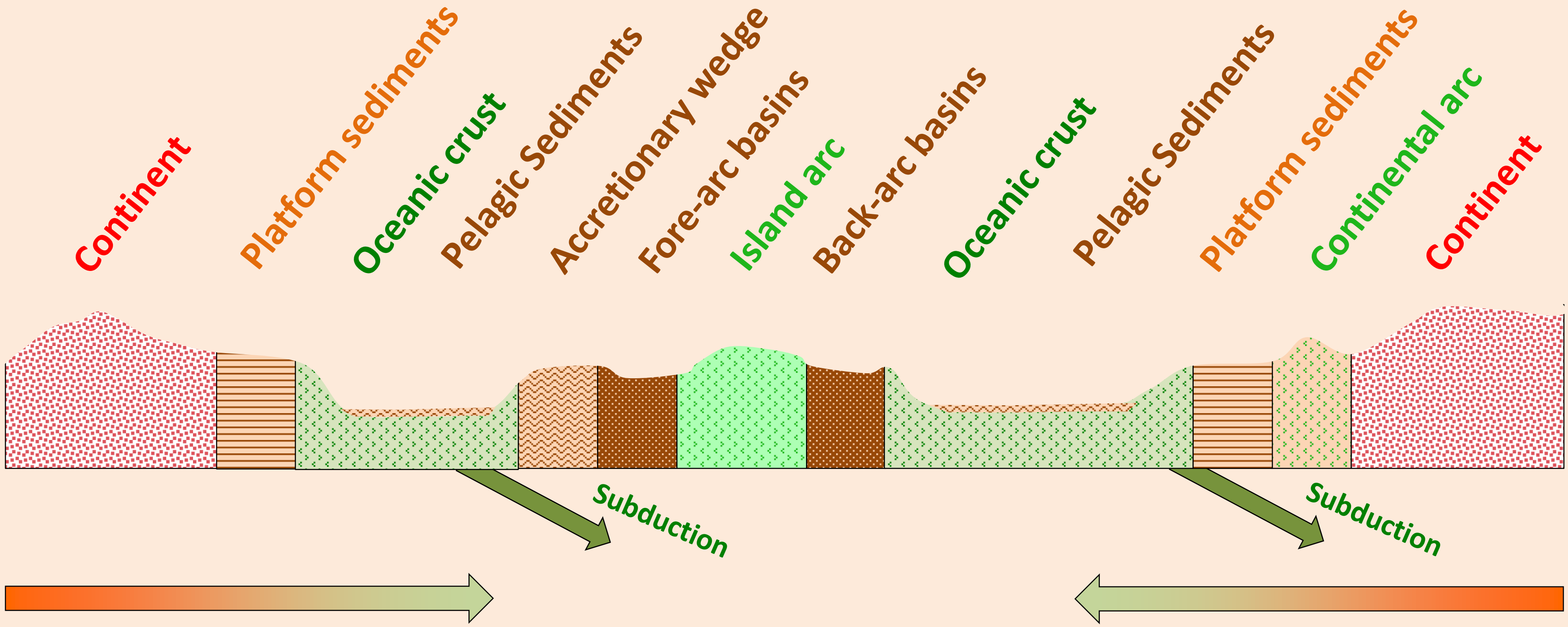
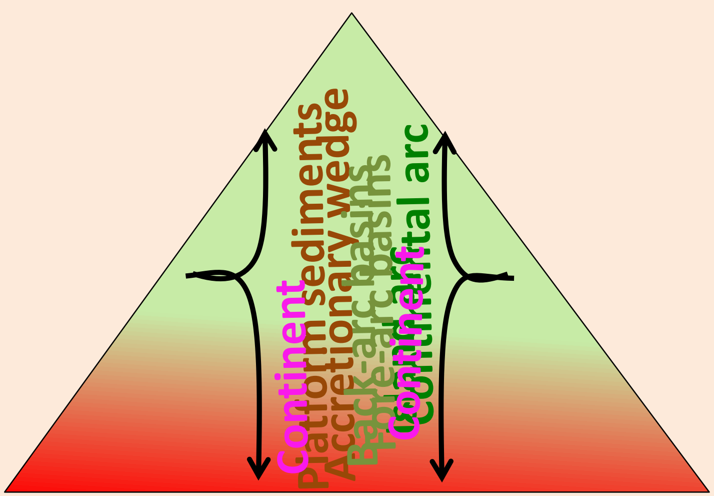
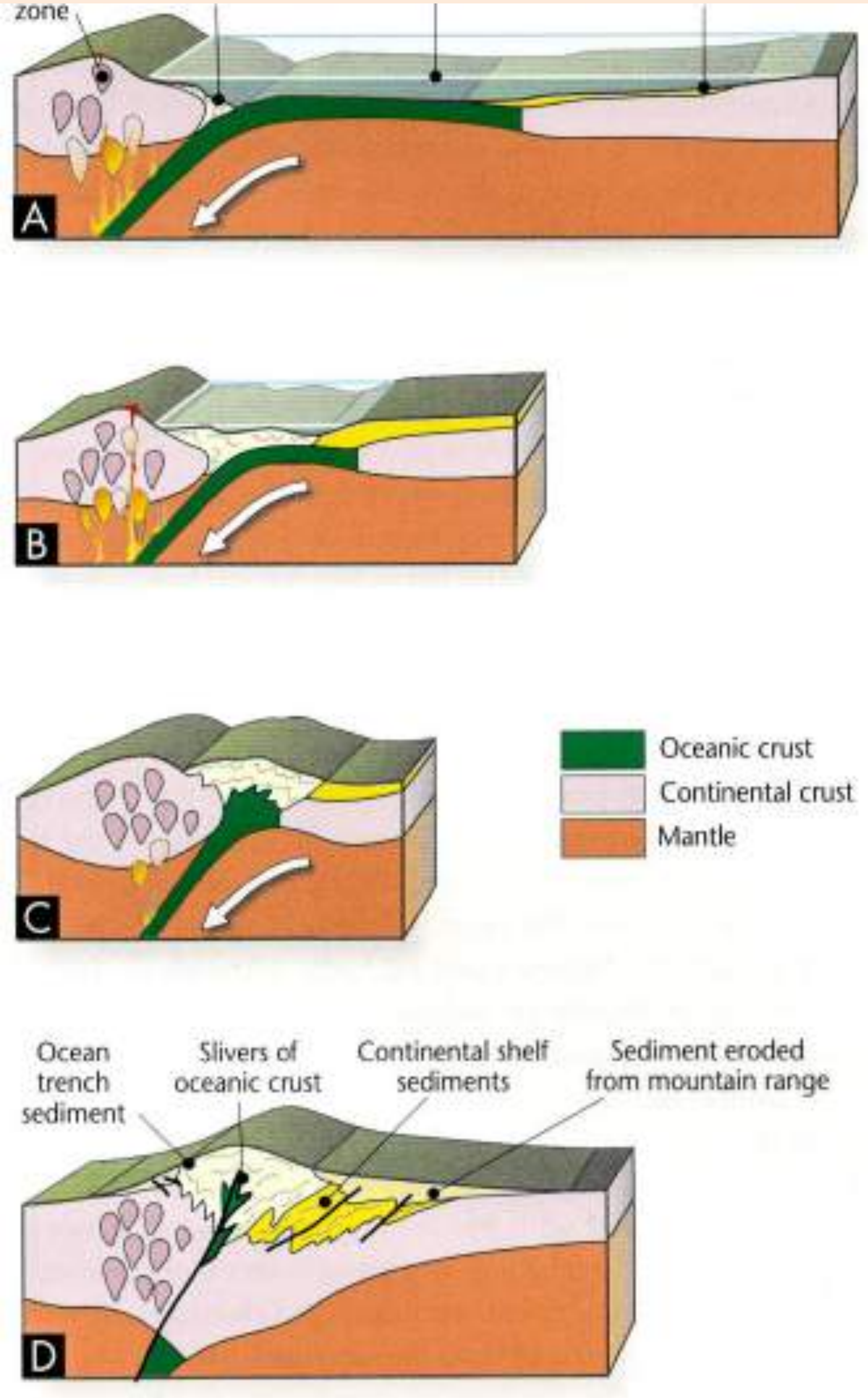


Plate tectonics

Stages in collision from initial island arcs with forearc basin and passive margin sediments and finally continental crust all piling up to produce mountains - OROGENISIS

Continent
Platform sediments
Accretionary wedge
Back-arc basins
Fore-arc basins
Island arc
Continental arc
Continent

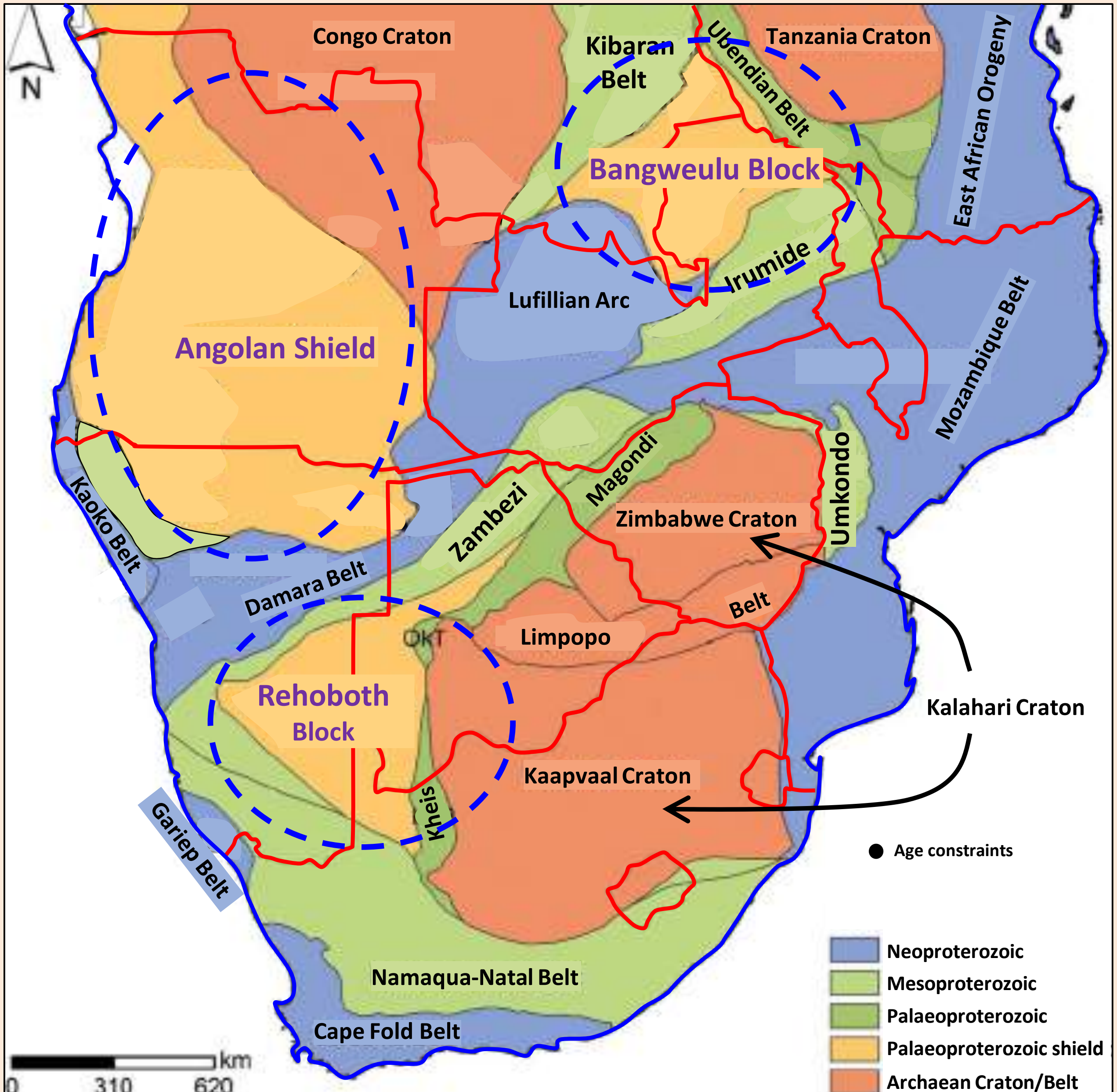




Supercontinent name	Assembly Age (Ma)	Comment
Vaalbara	3,600 – 2,800	Also described as a supercraton or just a continent
Ur	2,800 – 2,400	Described as both a continent and a supercontinent
Kenorland	2,700 – 2,100	Maybe two continents Superia and Sclavia
Columbia	1,820 – 1,350	
Rodinia	1,130 – 750	
Pannotia	633 – 573	
Gondwana	550 – 175	From the Carboniferous formed part of Pangaea
Pangaea	336 – 175	

GEOLOGICAL TIME SCALE						CONTINENT ASSEMBLY AND BREAKUP	
Ma	EPOCH	PERIOD		ERA	EON		
	Pleistocene	Quaternary		Cenozoic	PHANEROZOIC		
2	Pliocene	Neogene	Tertiary				
5	Miocene						
24	Oligocene	Palaeogene					
34	Eocene						
55	Palaeocene						
65		Cretaceous		Meso-zoic			
142		Jurassic					
205		Triassic				Break up Gondwana 220	
248		Permian		Palaeozoic			
290		Carboniferous					
354		Devonian					
417		Silurian					
443		Ordovician					
495		Cambrian					
545				Neo-	PROTEROZOIC	Assembly Gondwana 650 – 500	Pan African
1000				Meso-		Assembly Rodinia 1250 – 950	Kibaran
1600				Palaeo-		Assembly Columbia 2100 – 1800	Ubendian
						Limpopo Belt 2600 – 2000 ?	
2500				ARCHAEAN			

AFRICAN OROGENIC EVENTS SHIELDS AND BLOCKS



PAN AFRICAN ~ 550 Ma

Cape Fold Belt
Gariep belt
Kaoko Belt
Mozambique Belt
Damara Belt
Lufillian Arc

Gondwana

KIBARAN ~ 1000 Ma

Kibaran Belt
Irumide Belt
Zambezi Belt
Namaqua-Natal Belt
Umkondo

Rodinia

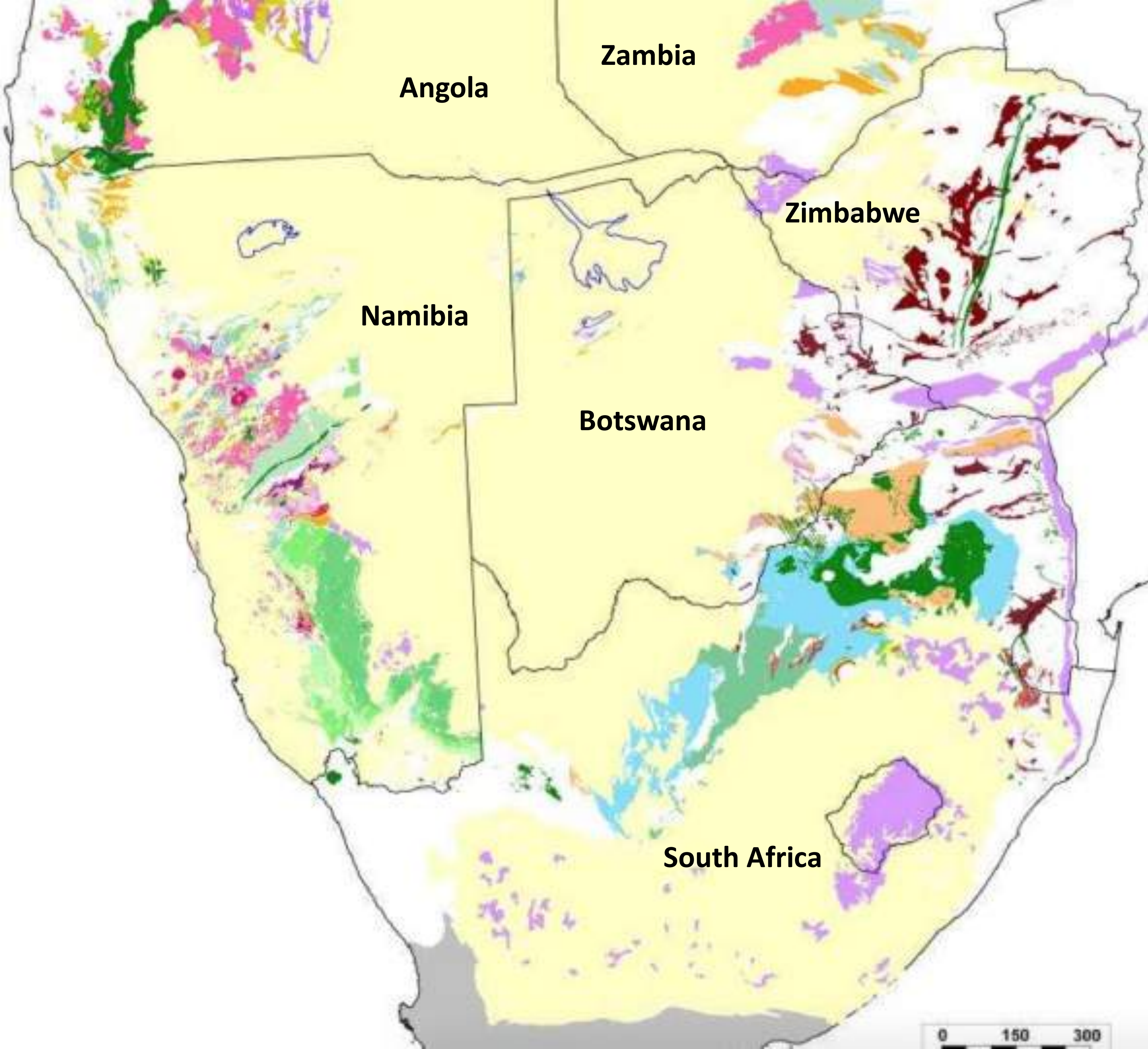
UBENDIAN ~ 2000 Ma

Ubendian Belt
Magondi-Kheis

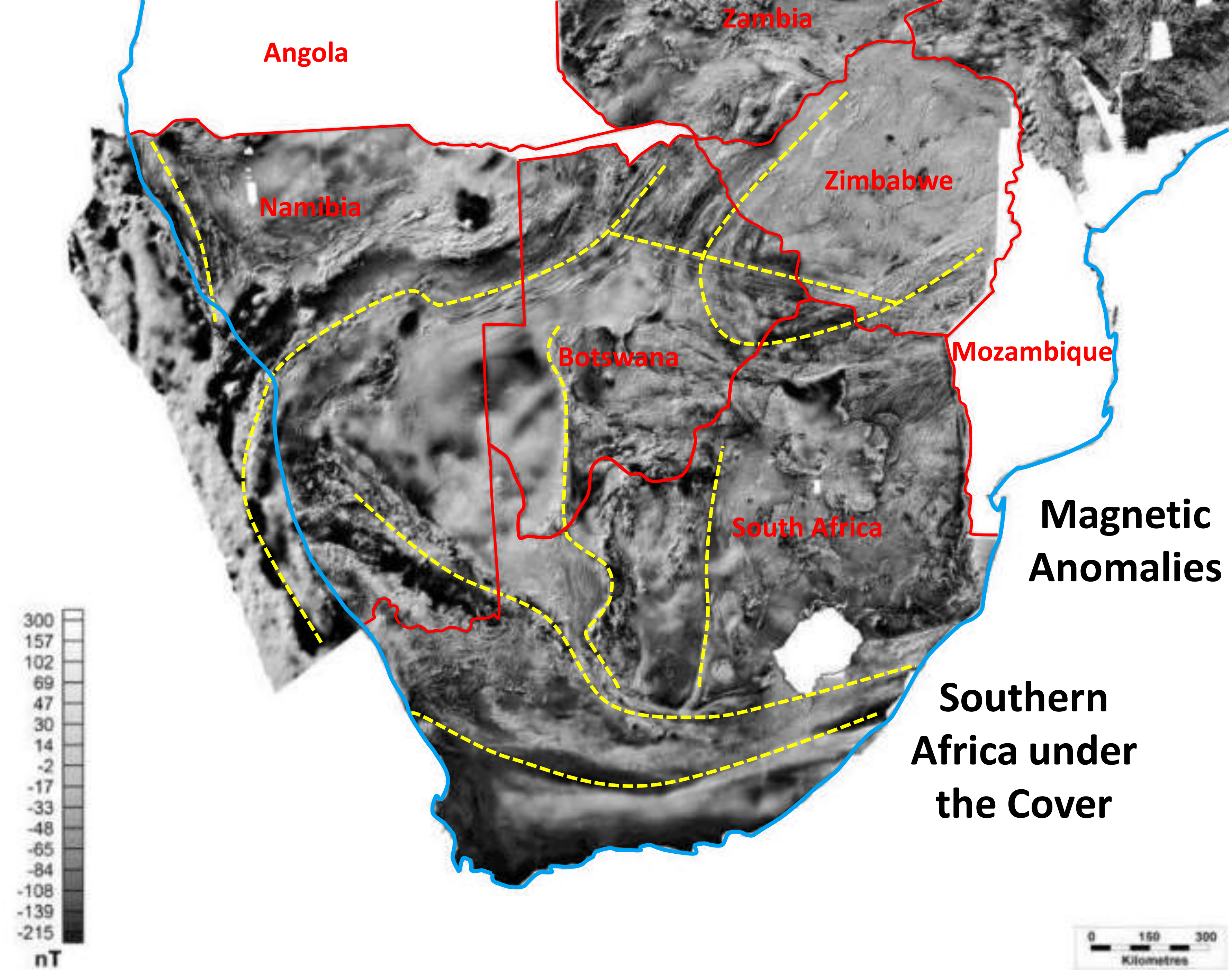
Columbia

ARCHAEAN

BLOCKS/SHIELDS
Archaean/Palaeoproterozoic often under younger cover



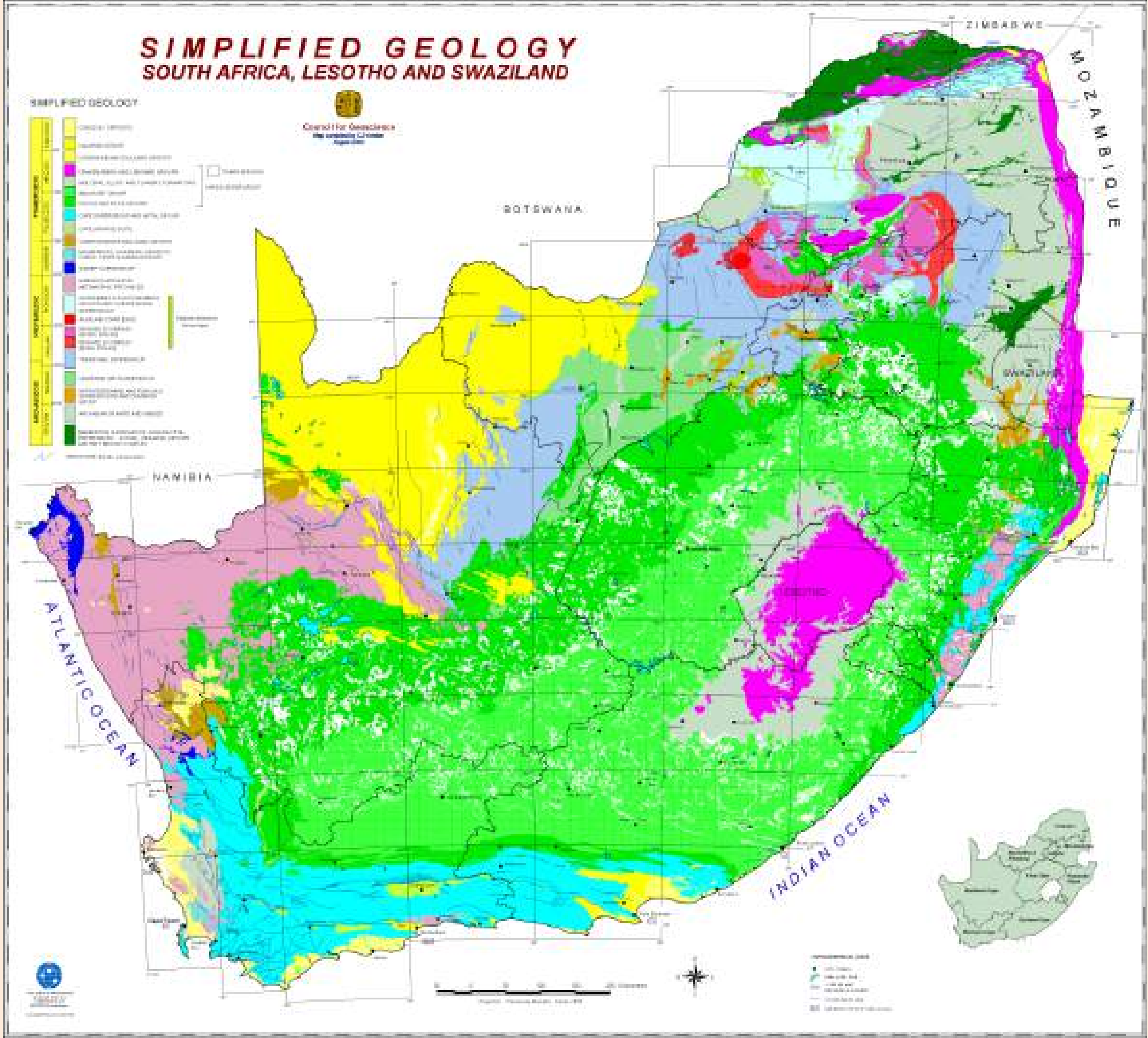
Southern Africa Phanerozoic Cover



Magnetic Anomalies

Southern Africa under the Cover

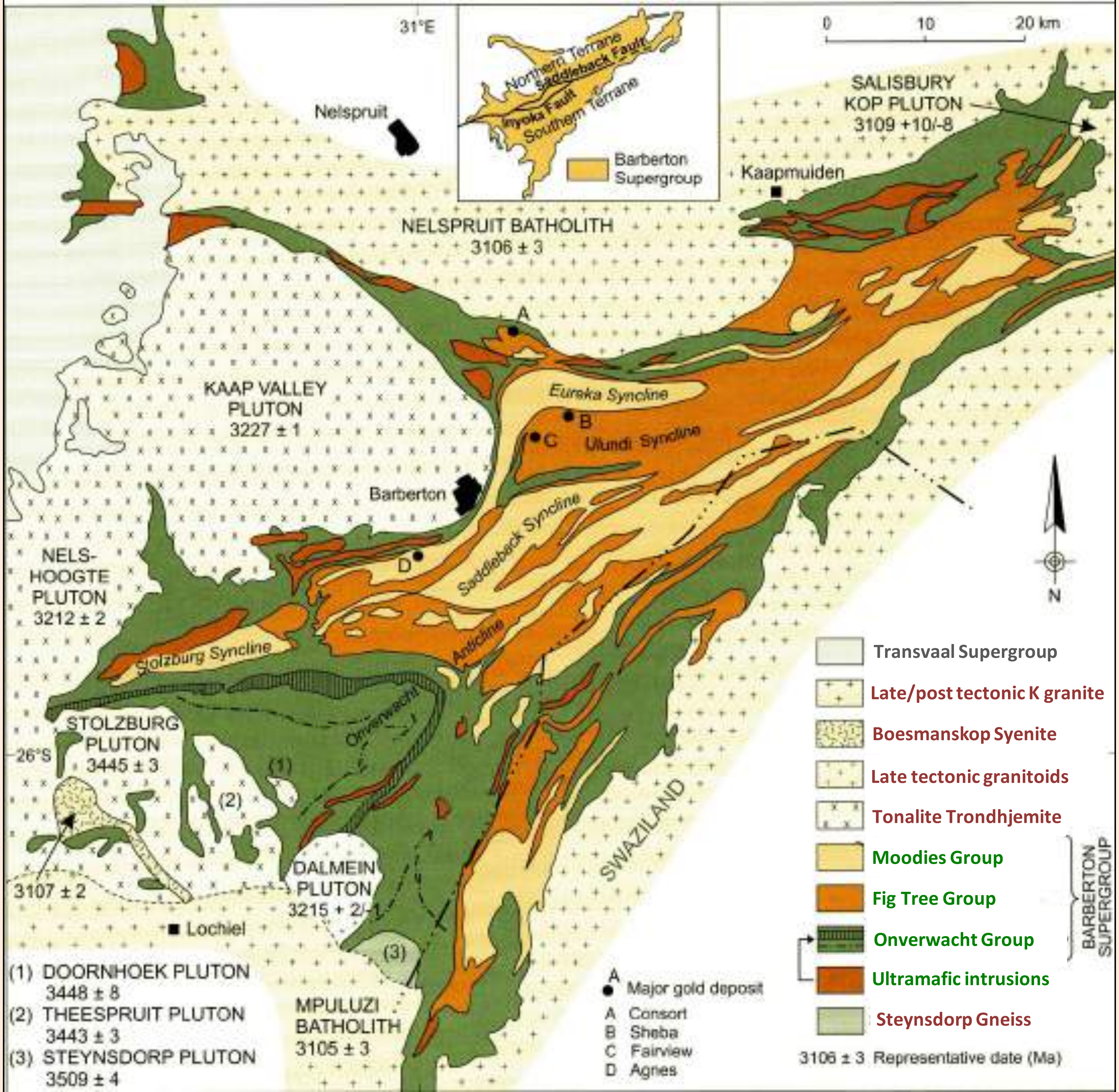
Geology South Africa



Southern African Stratigraphy – South Africa

65 Ma - present	Kalahari Supergroup	
183 Ma	Karoo Igneous Province	
300 – 182 Ma	Karoo Supergroup	
495 – 354 Ma	Cape Supergroup	
552 – 500 Ma	Cape Granite Suite	
550 – 530 Ma	Saldanian Belt	
2000 Ma	Magondi Kheis Orogeny	
1700 Ma	Waterberg/Soutpansberg Groups	
2055 Ma	Bushveld Complex	
2650 – 2050 Ma	Transvaal Supergroup	ARCHAEAN
2950 – 2720 Ma	Ventersdorp Supergroup	
3074 Ma	Witwatersrand Supergroup	
2900 Ma	Dominium Group (South Africa	
2990 – 2780 Ma	Pongola Supergroup	
3100 Ma	Archaean granite and gneiss	
2700 – 3600 Ma	Archaean greenstone belt Barberton	

BARBERTON



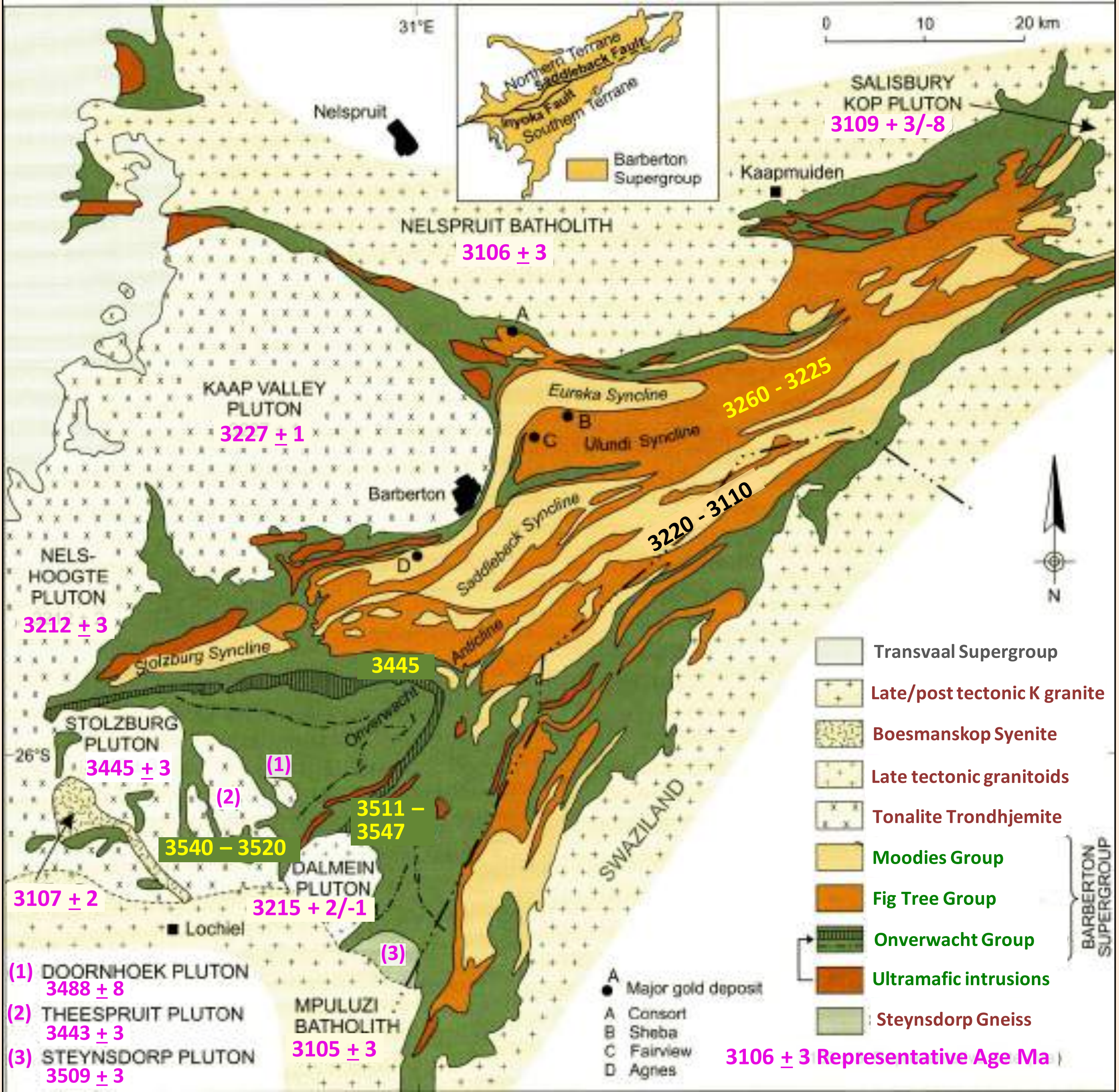
BARBERTON GREENSTONE BELT

BARBERTON SUPERGROUP STRATIGRAPHY

Moodies Group

Fig Tree Group

Onverwacht Group



BARBERTON GREENSTONE BELT

BARBERTON SUPERGROUP STRATIGRAPHY

ONVERWACHT GROUP

Weltevreden Fm
Komatiitic basalt komatiite

Mendon Fm
Basalt komatiite

Kromberg Fm
Basalt komatiite mafic tuff chert

Hooggenoeg Fm
Basalt komatiite silicified flow tops

Middle Marker Fm
Volcanic sediments chert

Komati Fm
Komatiite basalt

Theespruit Fm
Basalt komatiite felsic volcanic

Sandspruit Fm
Basalt komatiite


Barberton Mountain Land


Breccia


Pillow Geotrail Barberton


Accretionary Lapilli


Folded BIF

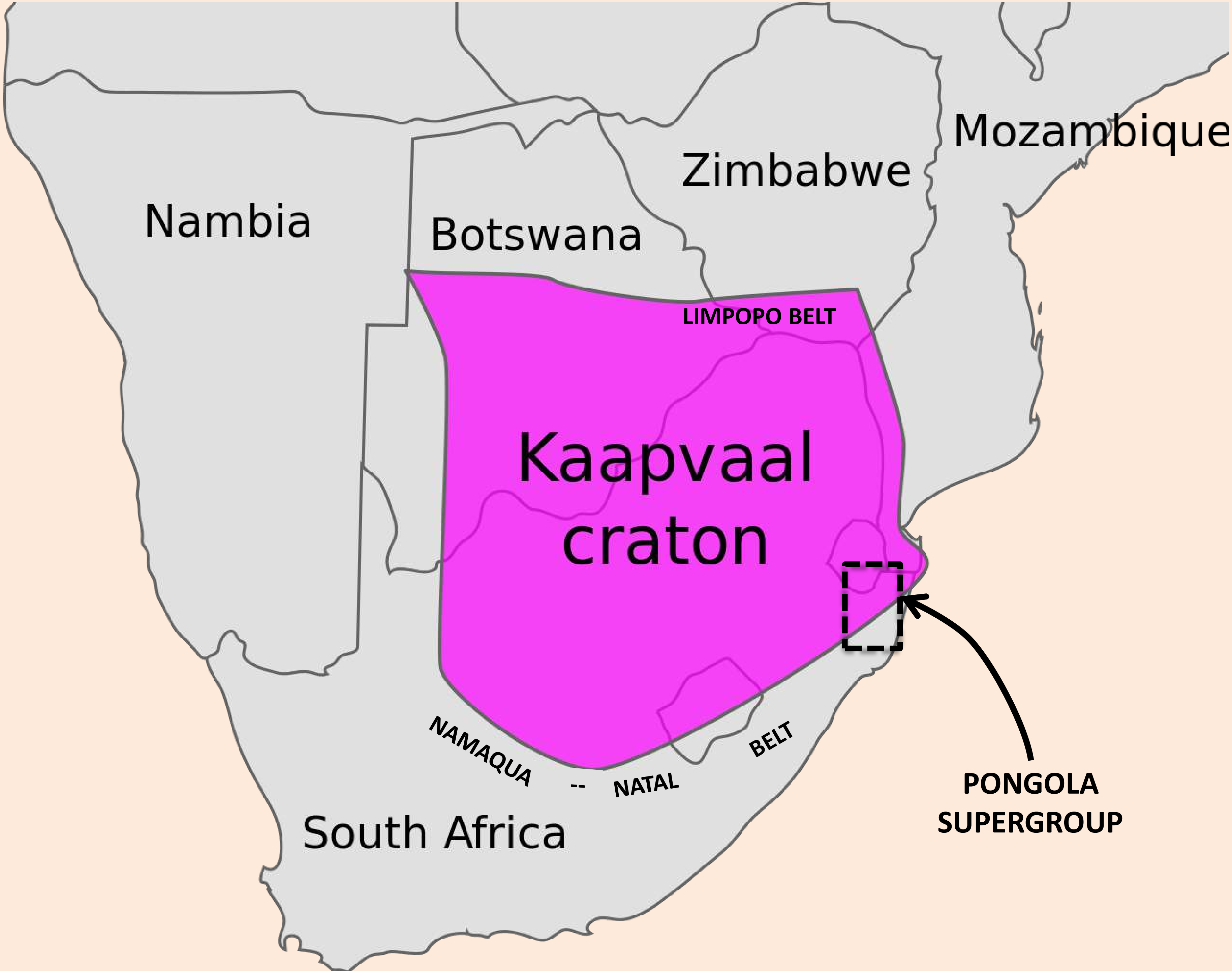

Ripple Marks


Silicified Tuff

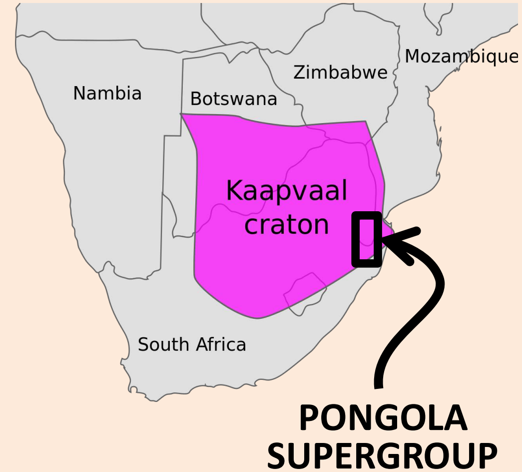

Tidal Cross Bedding

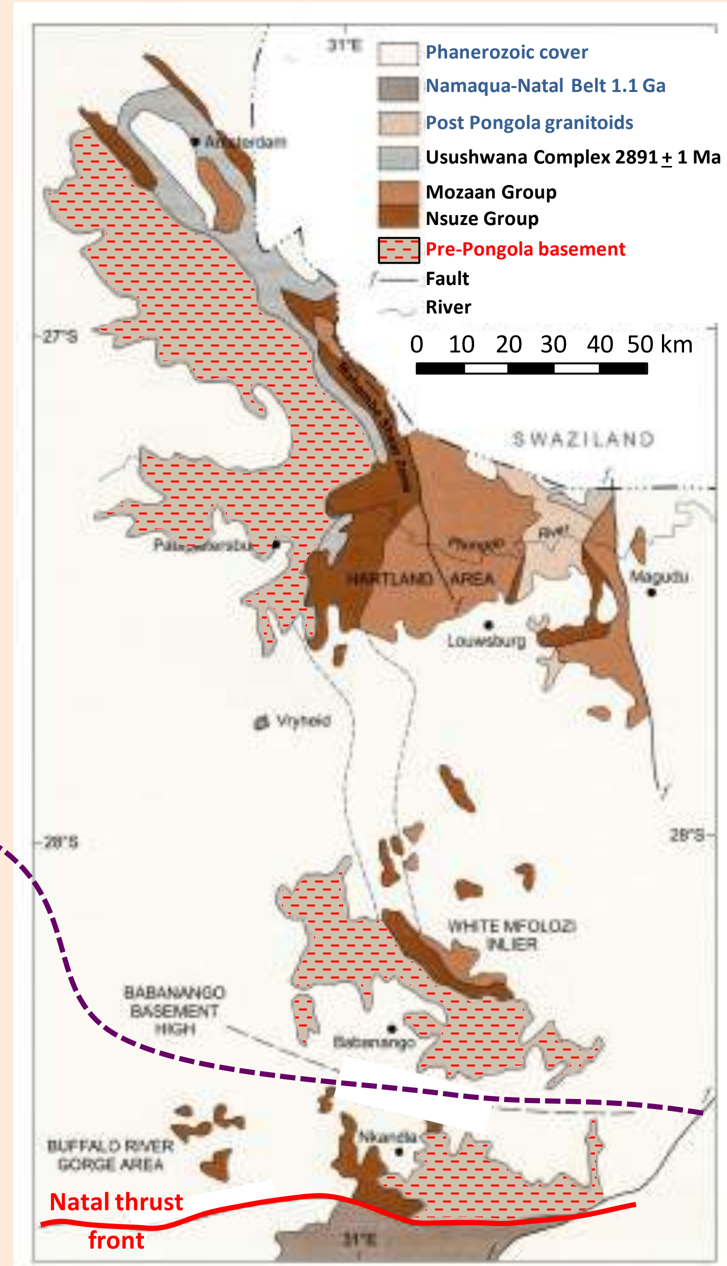

Spinifex Pyroxene

PONGOLA


Mozambique
Zimbabwe
Nambia
Botswana
LIMPOPO BELT
Kaapvaal craton
NAMAQUA -- NATAL BELT
PONGOLA SUPERGROUP
South Africa

PONGOLA SUPERGROUP





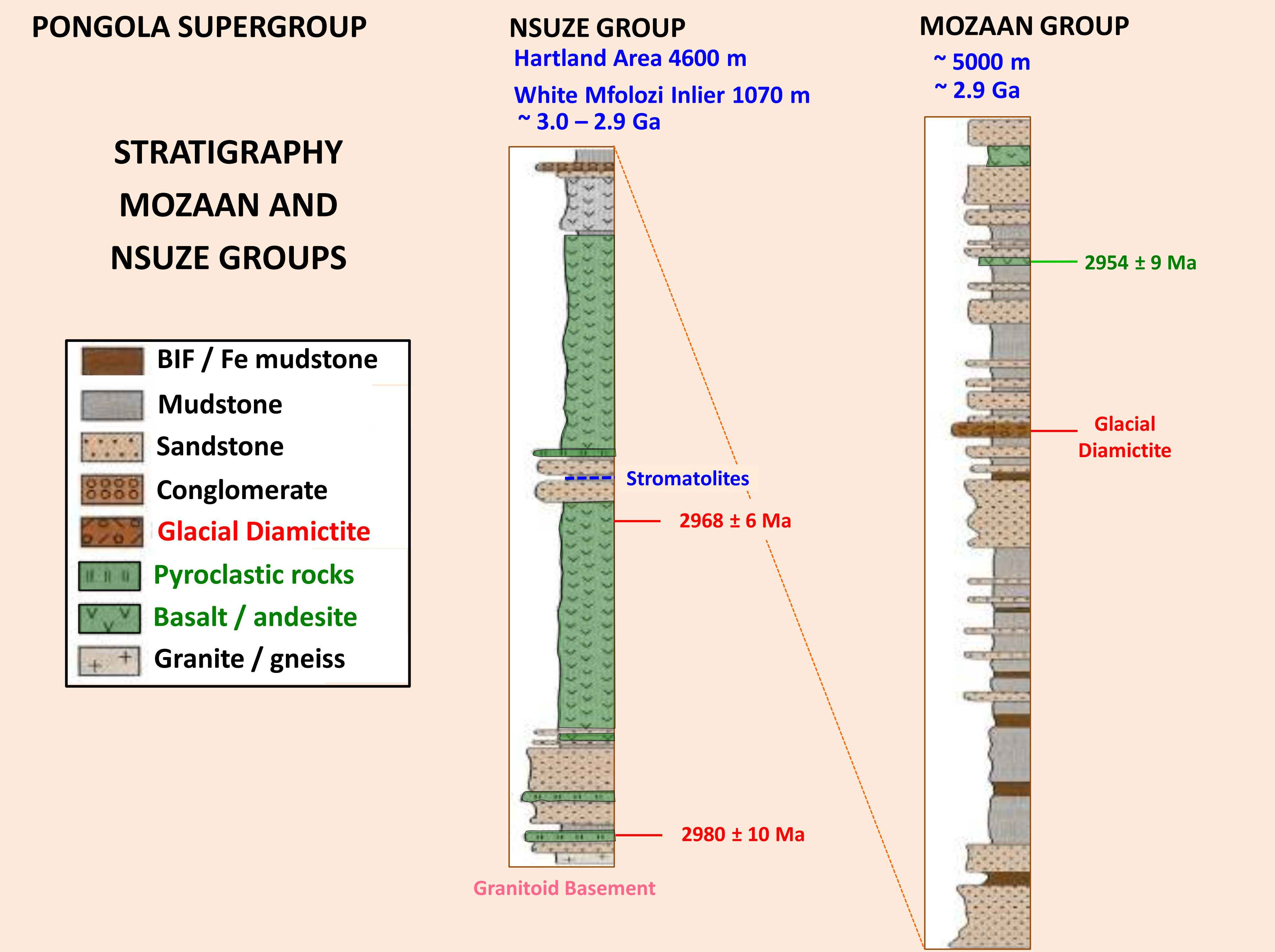
Mozaan and Nsuze Groups

Mozaan and Nsuze Groups

Nsuze Group

Main Pongola Basin

Nkandla Basin


PONGOLA SUPERGROUP
STRATIGRAPHY
MOZAAN AND
NSUZE GROUPS
BIF / Fe mudstone
Mudstone
Sandstone
Conglomerate
Glacial Diamictite
Pyroclastic rocks
Basalt / andesite
Granite / gneiss
NSUZE GROUP
Hartland Area 4600 m
White Mfolozi Inlier 1070 m
~ 3.0 – 2.9 Ga
Stromatolites
2968 ± 6 Ma
2980 ± 10 Ma
Granitoid Basement
MOZAAN GROUP
~ 5000 m
~ 2.9 Ga
2954 ± 9 Ma
Glacial
Diamictite

PONGOLA SUPERGROUP SUMMARY

NSUZE GROUP

Largely volcanic minor sedimentary

Deposition on stable >3.1 Ga continental crust

Base immature sediments granitic provenance with rapid facies variations

Rifting and basaltic/andesitic volcanicity minor sediments with non-marine stromatolites

MOZAAN GROUP

Mainly sedimentary minor volcanic ~ 2.9Ga

Epicratonic with repeated marine incursions conglomerate sandstone and mudstone BIF

Late rifting with sedimentation associated with load-induced basaltic/andesitic volcanicity

Diamictite evidence of glaciation

Rapid facies variations differential subsidence transgressions and regressions

PONGOLA SUPERGROUP NSUZE GROUP




PONGOLA SUPERGROUP MOZAAN GROUP

WITWATERSRAND TRIAD

VENTERSDORP

WITWATERSRAND

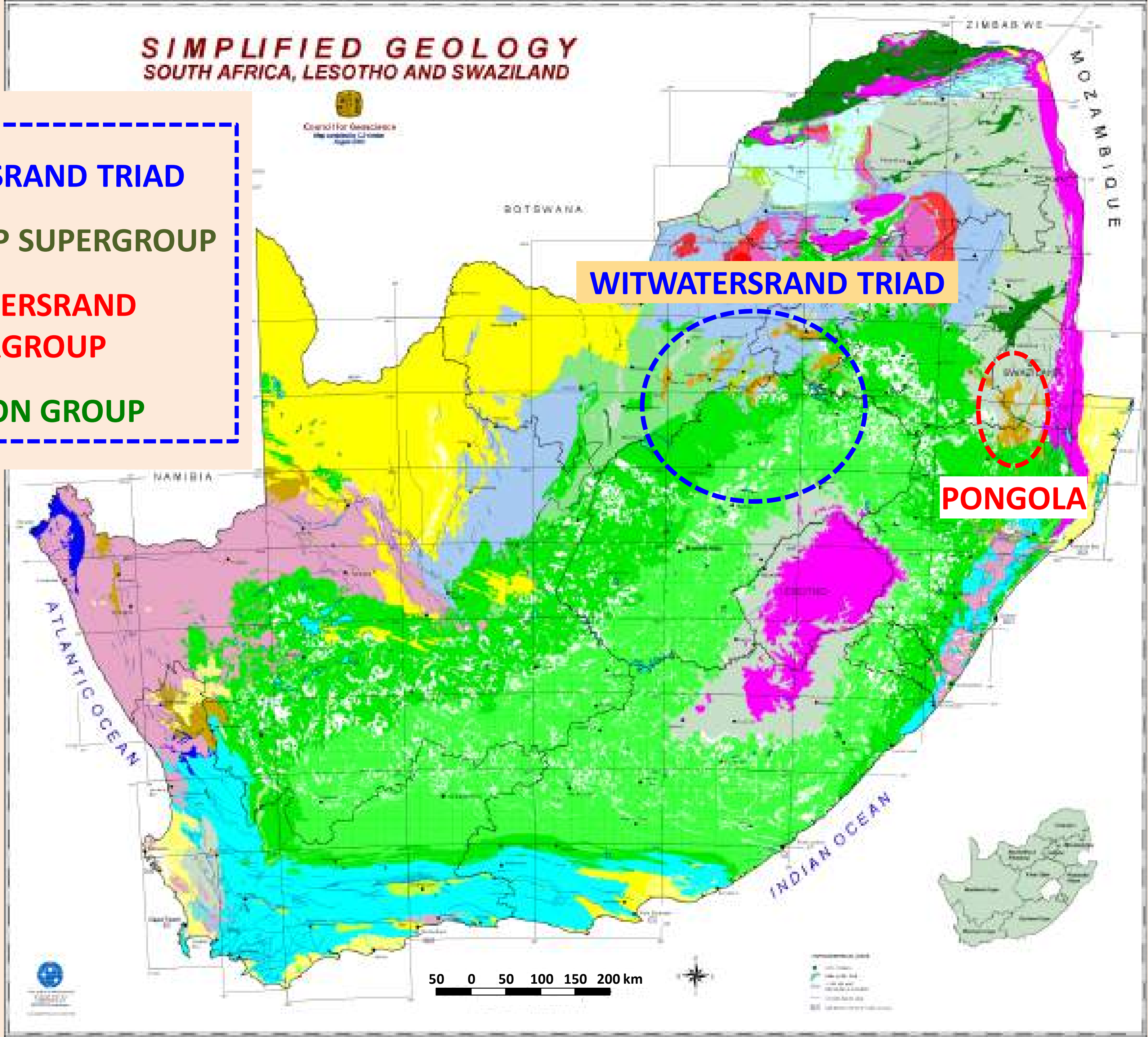
DOMINION

WITWATERSRAND TRIAD

VENTERSDORP SUPERGROUP

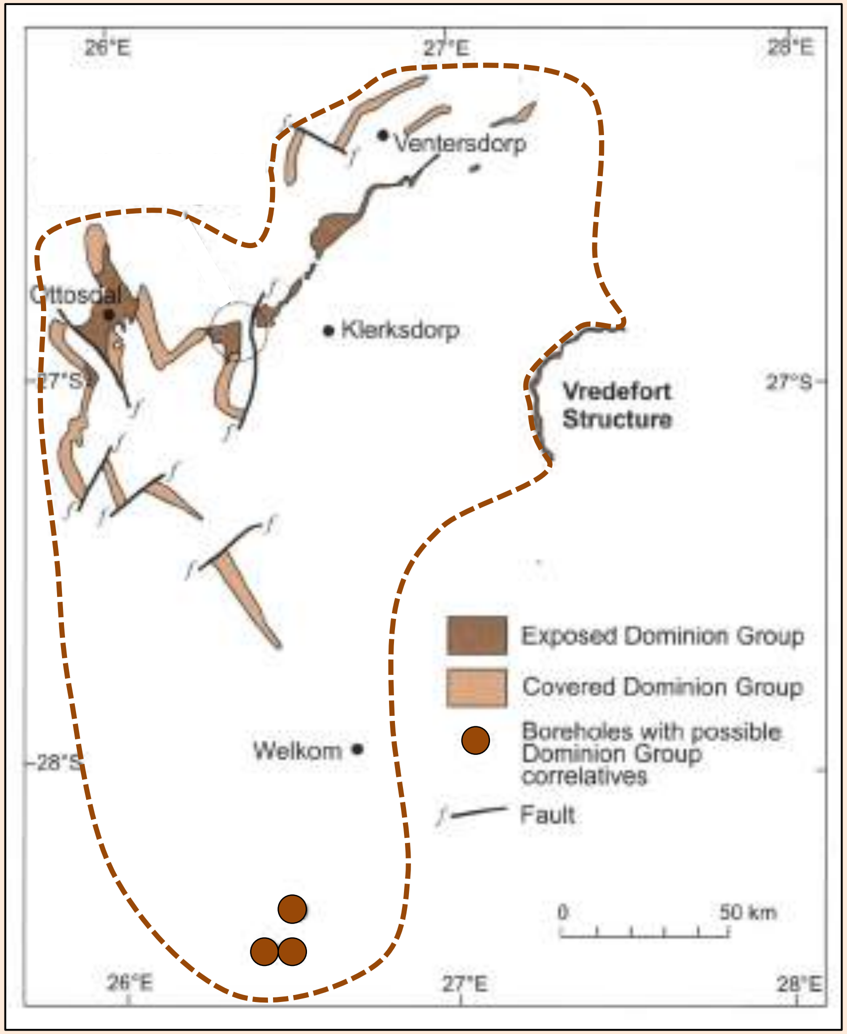
WITWATERSRAND SUPERGROUP

DOMINION GROUP



DOMINION

DOMINION GROUP



Lowest member of the Witwatersrand Triad

Unconformable on Archaean basement granitoid

Well-developed palaeosol below the sediments

Basal conglomerates mined for gold (Dominion Reef)

Unconformably overlain by Witwatersrand Supergroup

Age 3074 $\pm$ 6 Ma **Pongola 3.1 – 2.9 Ga**

STRATIGRAPHY

Syferfontein Formation

Rhenosterhoek Formation

DOMINION GROUP

STRATIGRAPHY

Syferfontein Formation ~300 - >1500 m

Felsic & minor mafic volcanics of variable proportions and thickness

Rhenosterhoek Formation 200 - >1500 m

Dominantly mafic with minor felsic volcanics variable proportions and thickness

Initial deposition on uneven topography – variable facies and thickness

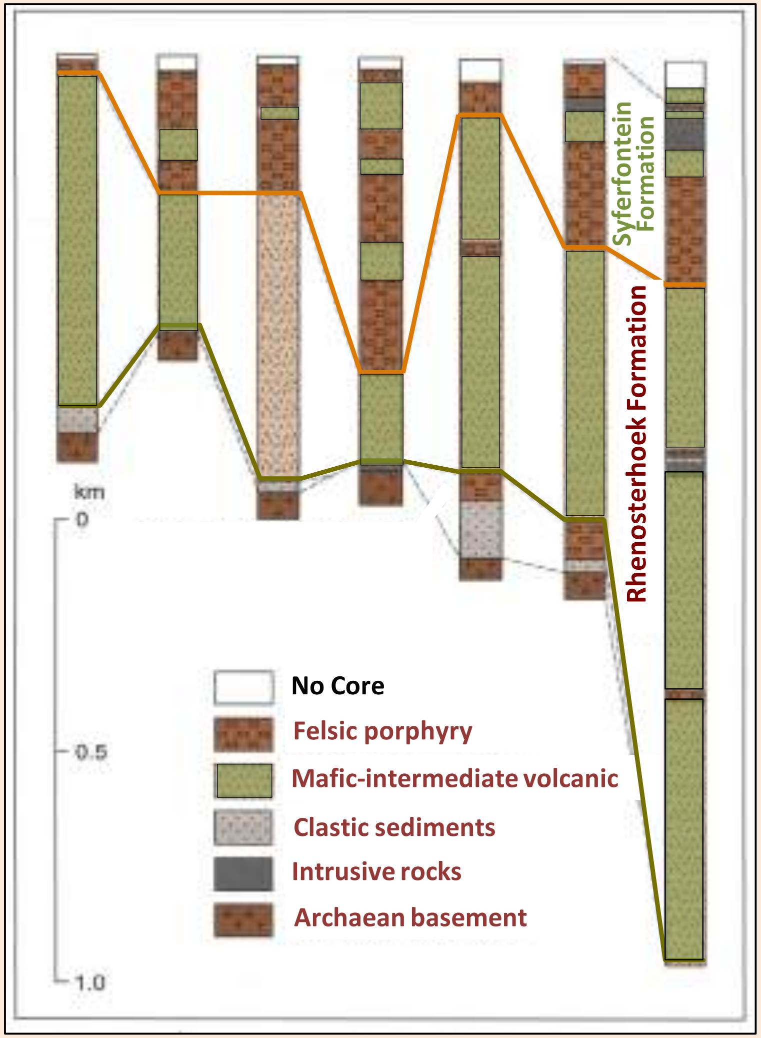
Variations in volcanic thickness – proximity to vents and topography

TECTONIC MODELS AND EVOLUTION

Lithospheric thinning and rifting of continental crust

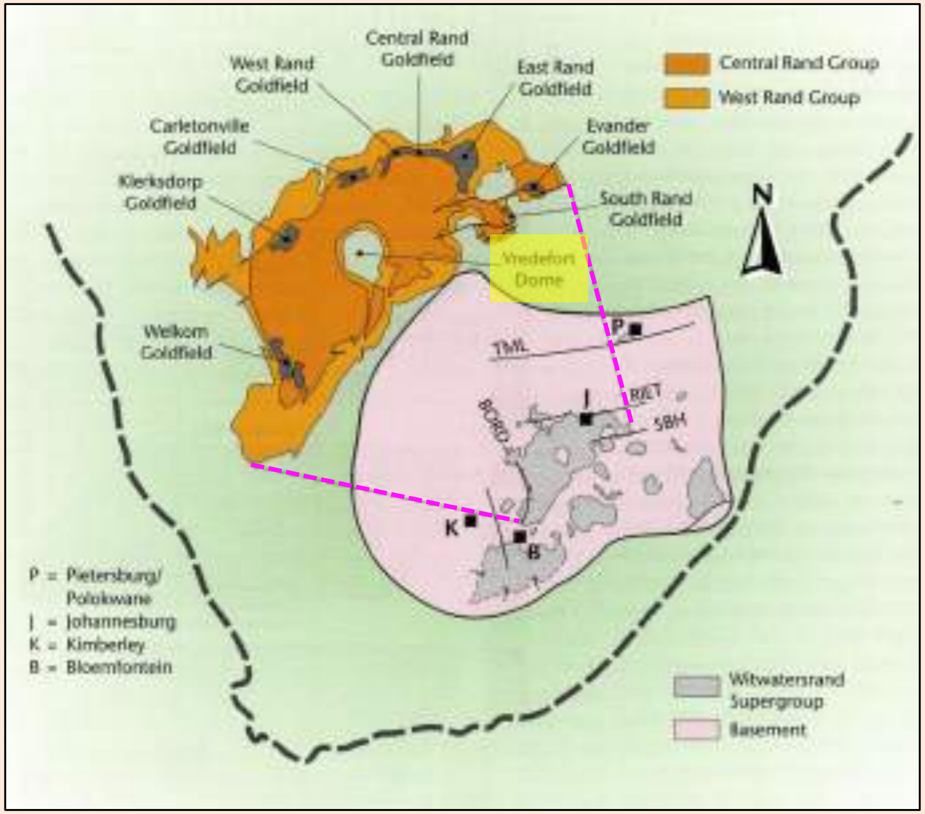
Pongola and Dominium Groups Proterozoic-style basins in the Archaean

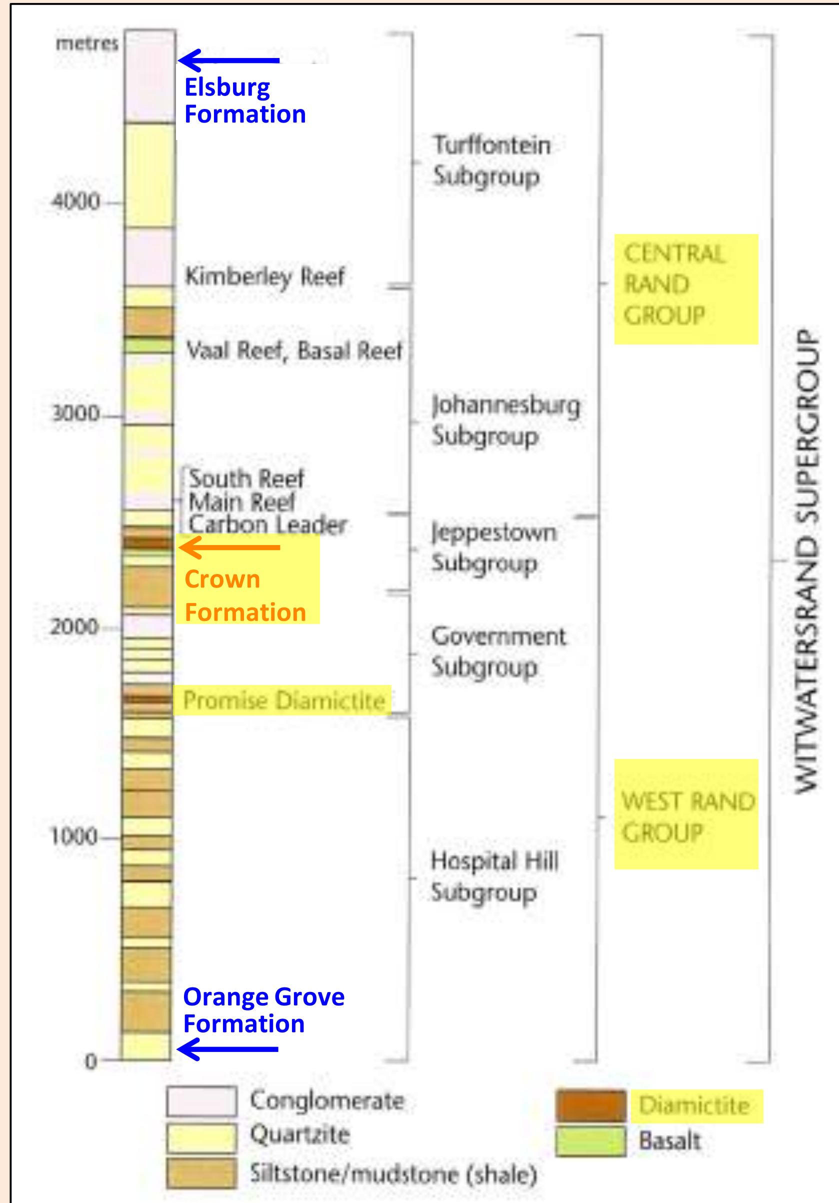
Distribution immediately below Witwatersrand Supergroup and must have tectonic associations



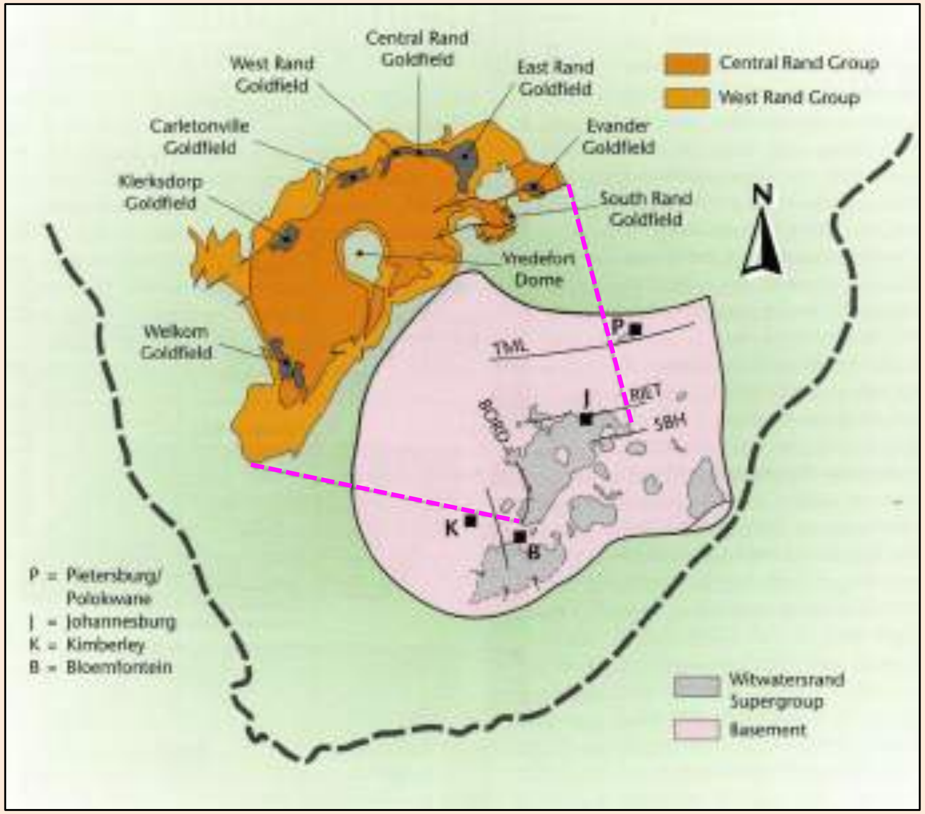
WITWATERSRAND

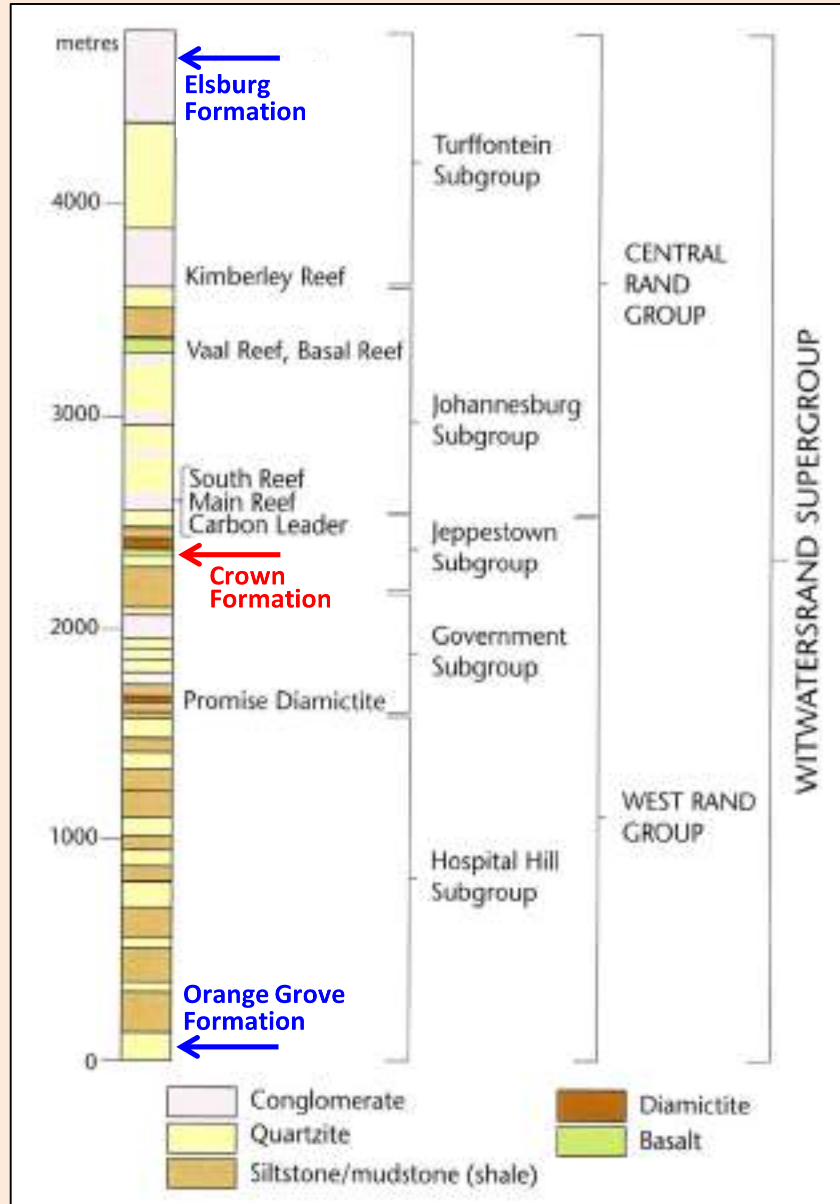
WITWATERSRAND SUPERGROUP





WITWATERSRAND SUPERGROUP





Ventersdorp Volcanics	2714 ± 8 Ma
Elsburg Formation detrital zircon	2894 Ma
Crown Formation volcanic	2914 ± 8 Ma
Orange Grove Formation detrital zircons	2970 - 3330 Ma
Dominion Group	3074 ± 6 Ma

Age ~ 2950 – 2720 Ma ~ 230 Ma depositional life

May be a short depositional break between Wits and Ventersdorp

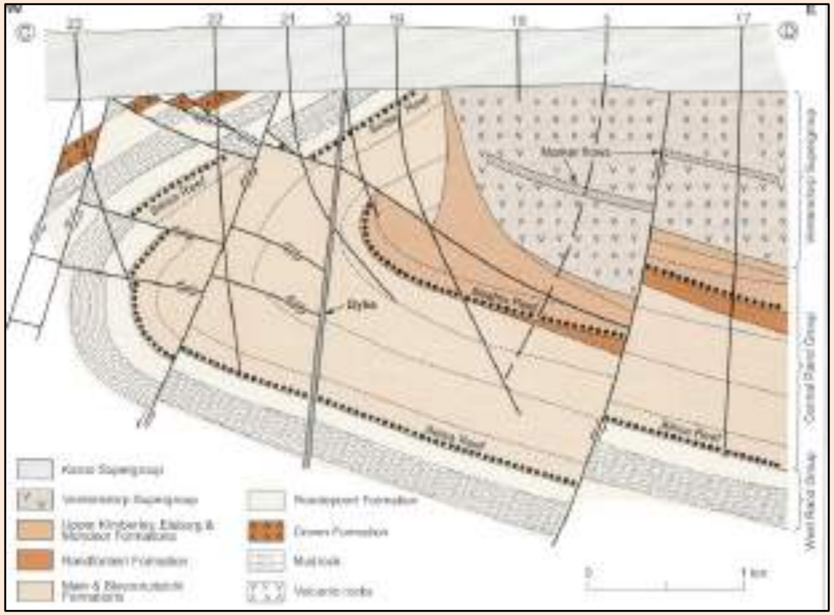
WITWATERSRAND SUPERGROUP STRATIGRAPHY

Central Rand Group	Turffontein Subgroup	Quartzite and conglomerate some gold braided plains with conglomerates at top
	Johannesburg Subgroup	Quartzites braided streams conglomerates with transgression/regression repetition contains much of the gold
West Rand Group	Jeppestown Subgroup	Variable from conglomerate to BIF with several glacial diamictite beds and widespread basalt/andesite
	Government Subgroup	Lithologically diverse from conglomerate to BIF with several glacial diamictite beds
	Hospital Hill Subgroup	Orthoquartzites shallow marine subtidal with distal siltstone, shale and BIF

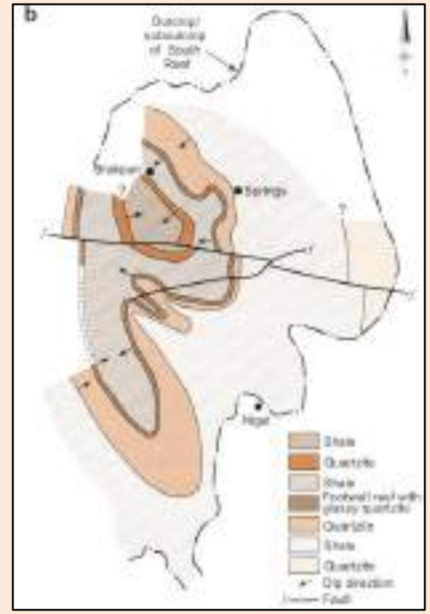
Disconformities and unconformities throughout the succession indicating water level changes

~ 230 Ma depositional life

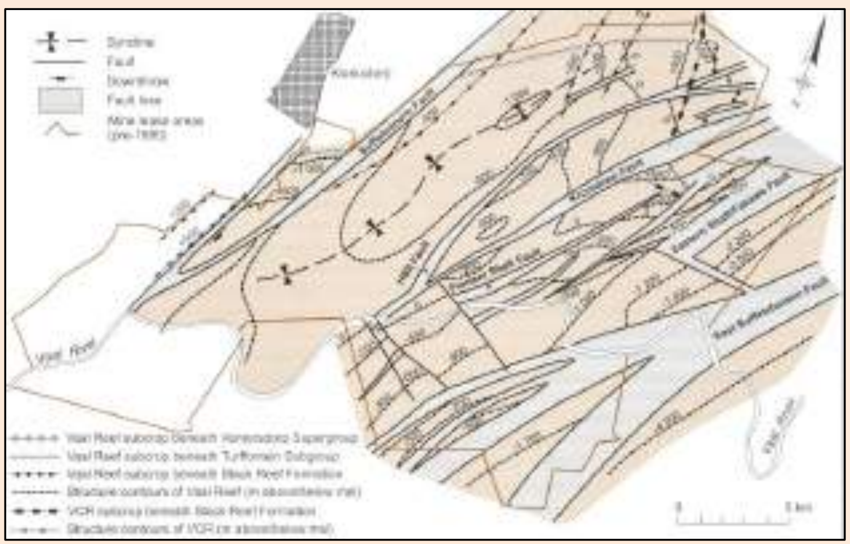
WITWATERSRAND SUPERGROUP STRUCTURAL COMPLEXITY



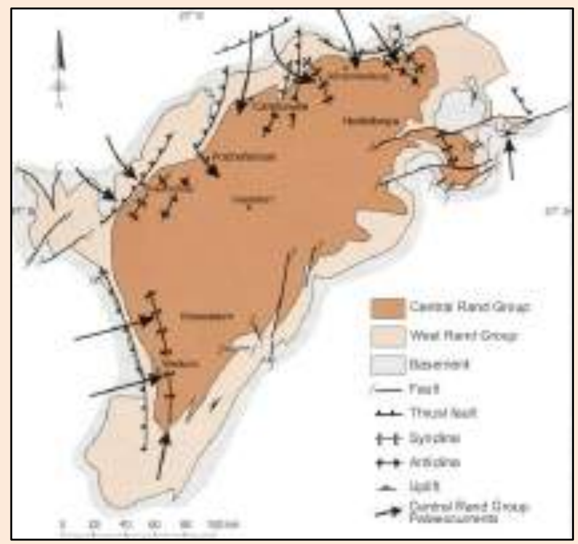
FREE STATE GOLDFIELD



EAST RAND GOLDFIELD

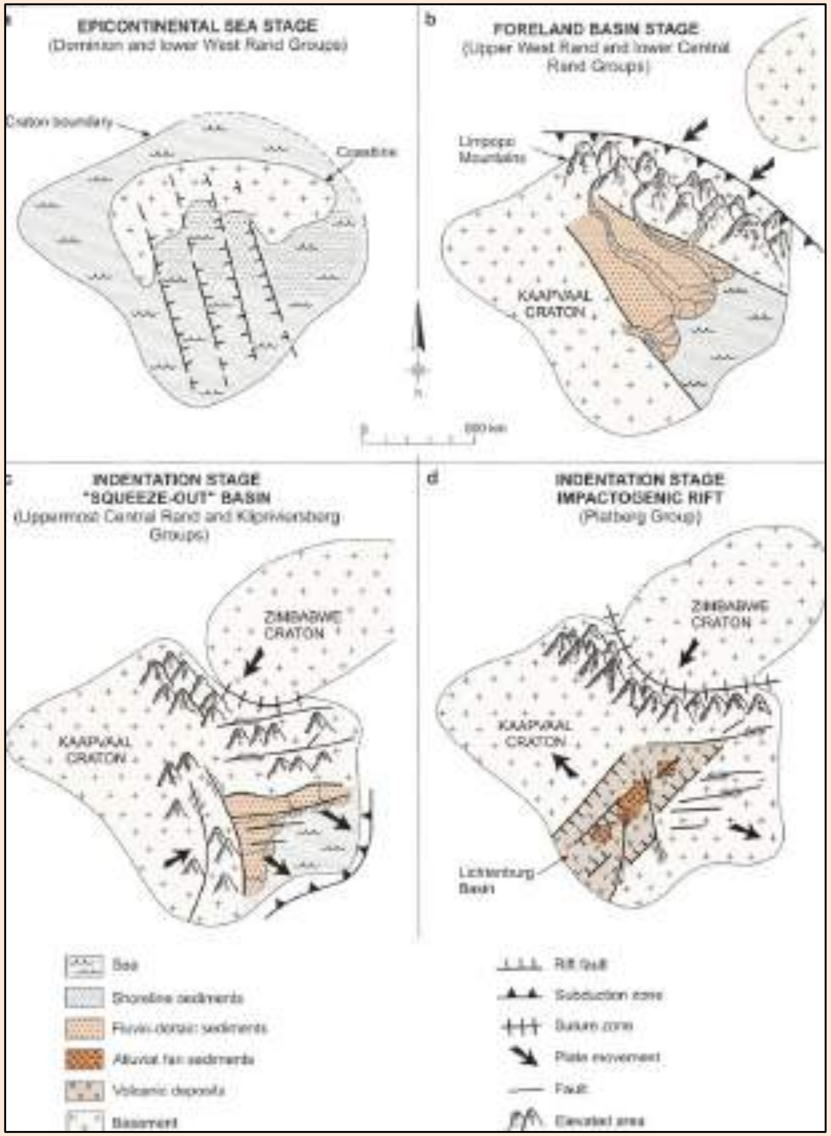


KLERKSDORP GOLDFIELD

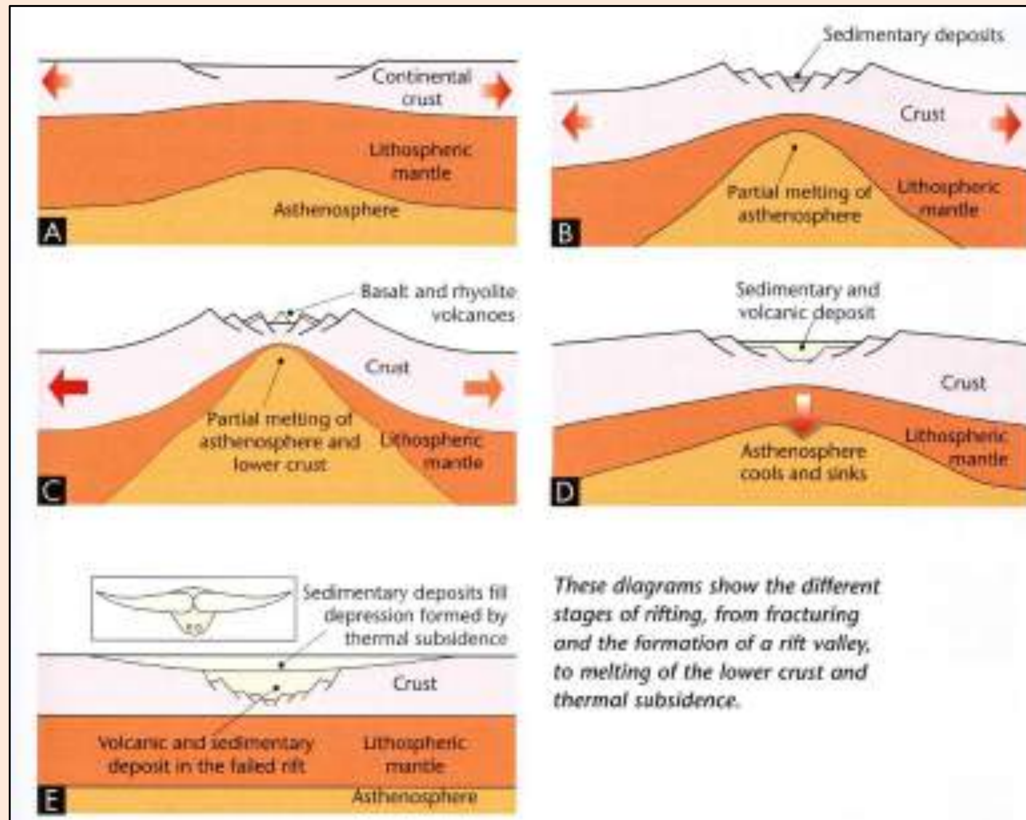


CENTRAL RAND GOLDFIELD

WITWATERSRAND SUPERGROUP ORIGIN

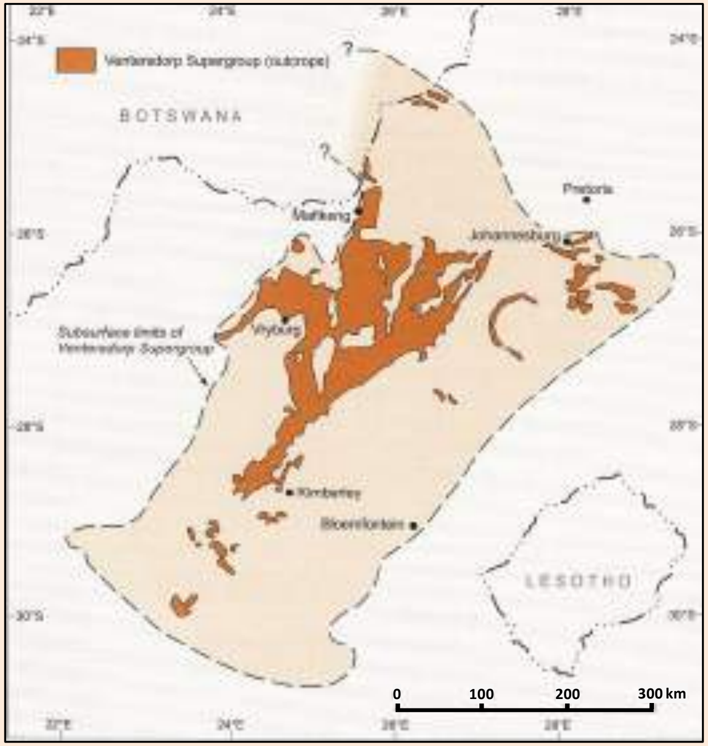


Rifting in marginal marine setting with later sedimentation affected by Limpopo collision??



VENTERSDORP

VENTERSDORP SUPERGROUP



Ventersdorp Supergroup

Volcanic sedimentary

Unconformity

Witwatersrand Supergroup

Sedimentary

Unconformity

Dominion Group

Sedimentary volcanic

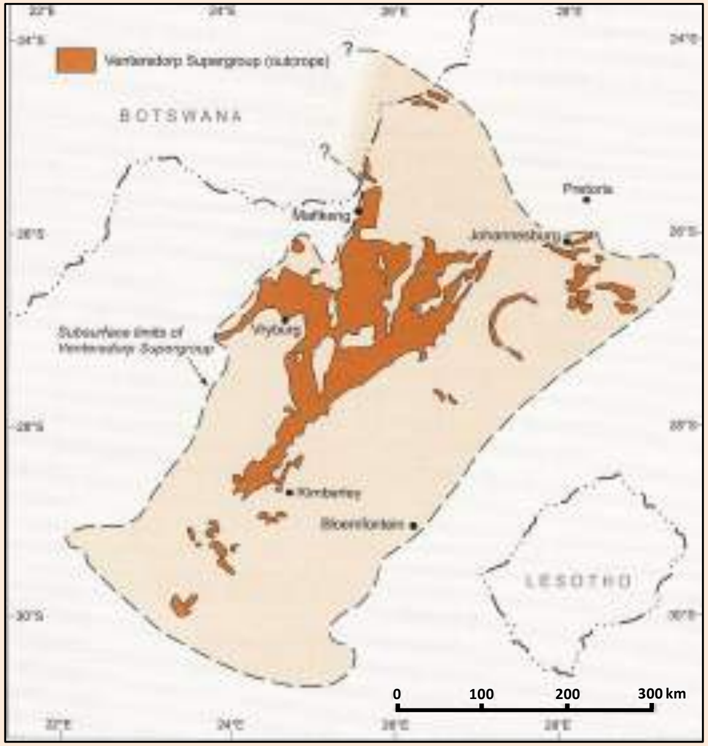
Large aerial extent (700 x 300 km) mostly under Karoo / Transvaal Supergroups cover but delineated by drilling

Low greenschist metamorphism

Elongate mantle plume with melting at shallow depth ~ 18 km

Mantle source with little crustal contamination

VENTERSDORP SUPERGROUP



Stromatolitic limestone chert

Shale siltstone

Sandstone greywacke

Conglomerate breccia

Mafic lava tuff

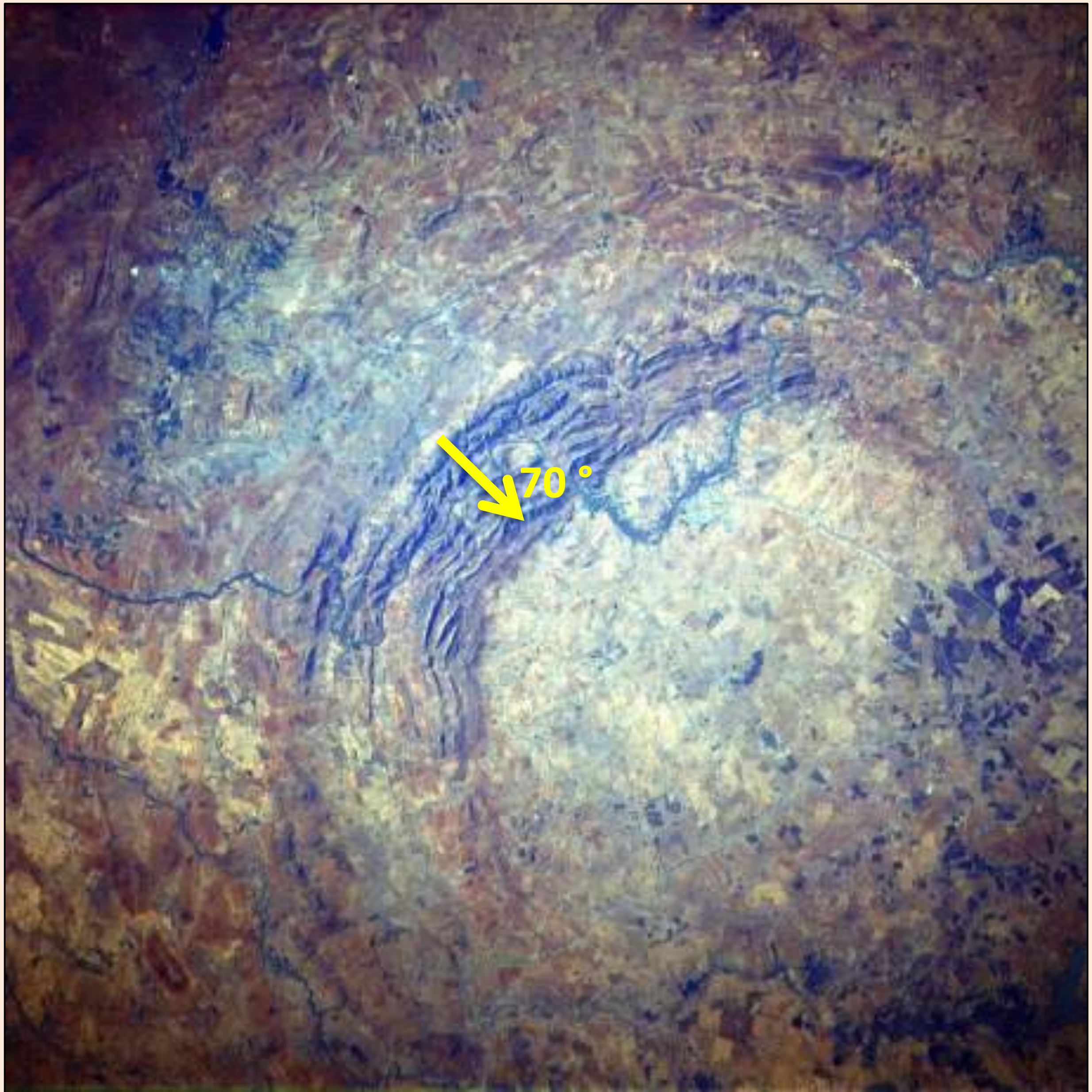
Intermediate lava

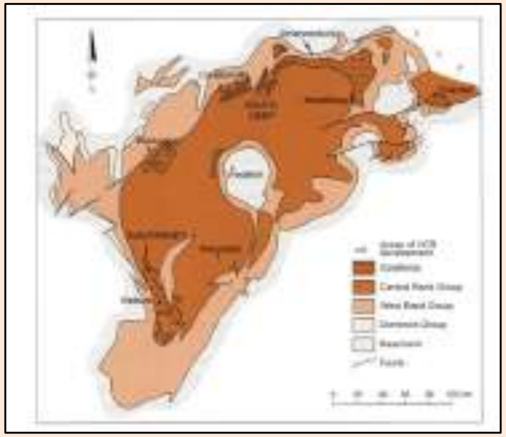
Felsic lava

Komatiitic lava

VREDEFORT IMPACT STRUCTURE

WITWATERSRAND SUPERGROUP
Vredefort Impact Structure





Vredefort Impact Structure

300 km across after impact

10 – 15 km Meteorite

Current structure 70 km

Impact at 2023 ± 4 Ma

Multiple ringed structure

Impacted

Dominion

Witwatersrand

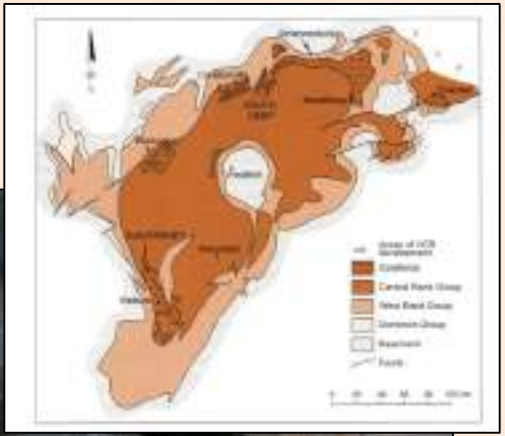
Ventersdorp

Transvaal

Archaean granitoids

WITWATERSRAND SUPERGROUP

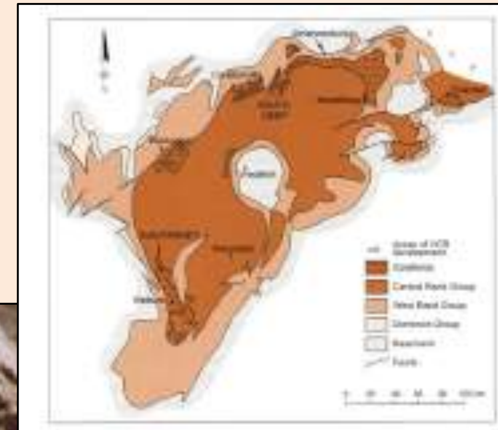
Vredefort Impact Structure



WITWATERSRAND SUPERGROUP

Vredefort Impact Structure

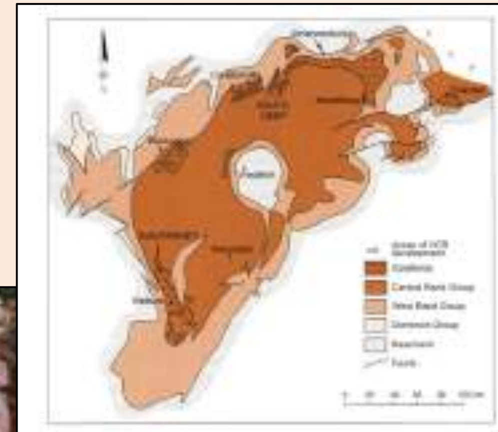
Shatter Cones



WITWATERSRAND SUPERGROUP

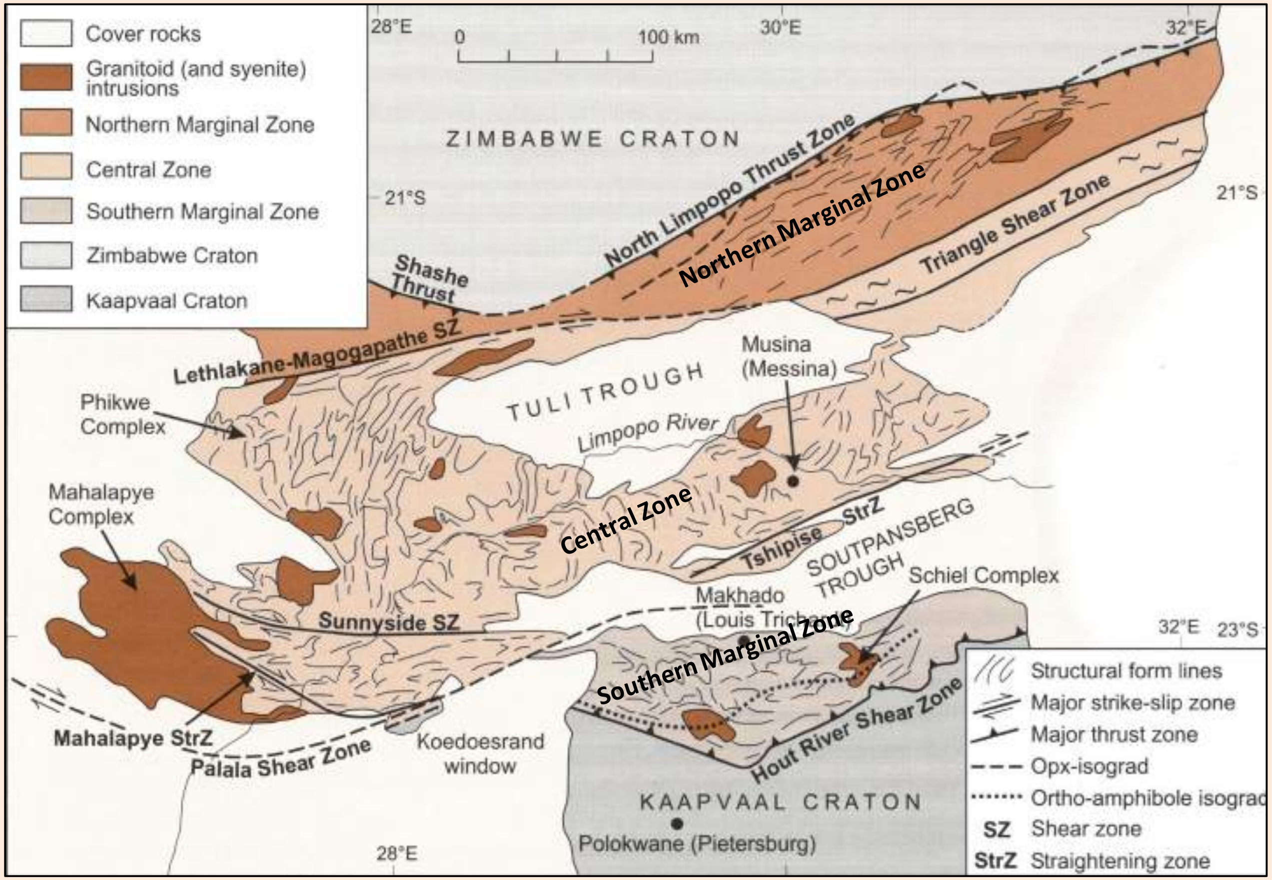
Vredefort Impact Structure

Pseudotachylite



LIMPOPO MOBILE BELT

LIMPOPO BELT



Linear metamorphic belt

700 km exposed

~ 1000 km - cover E and W

200 km N to S

Arcuate – based on outcrop east / center and geophysics west (Botswana)

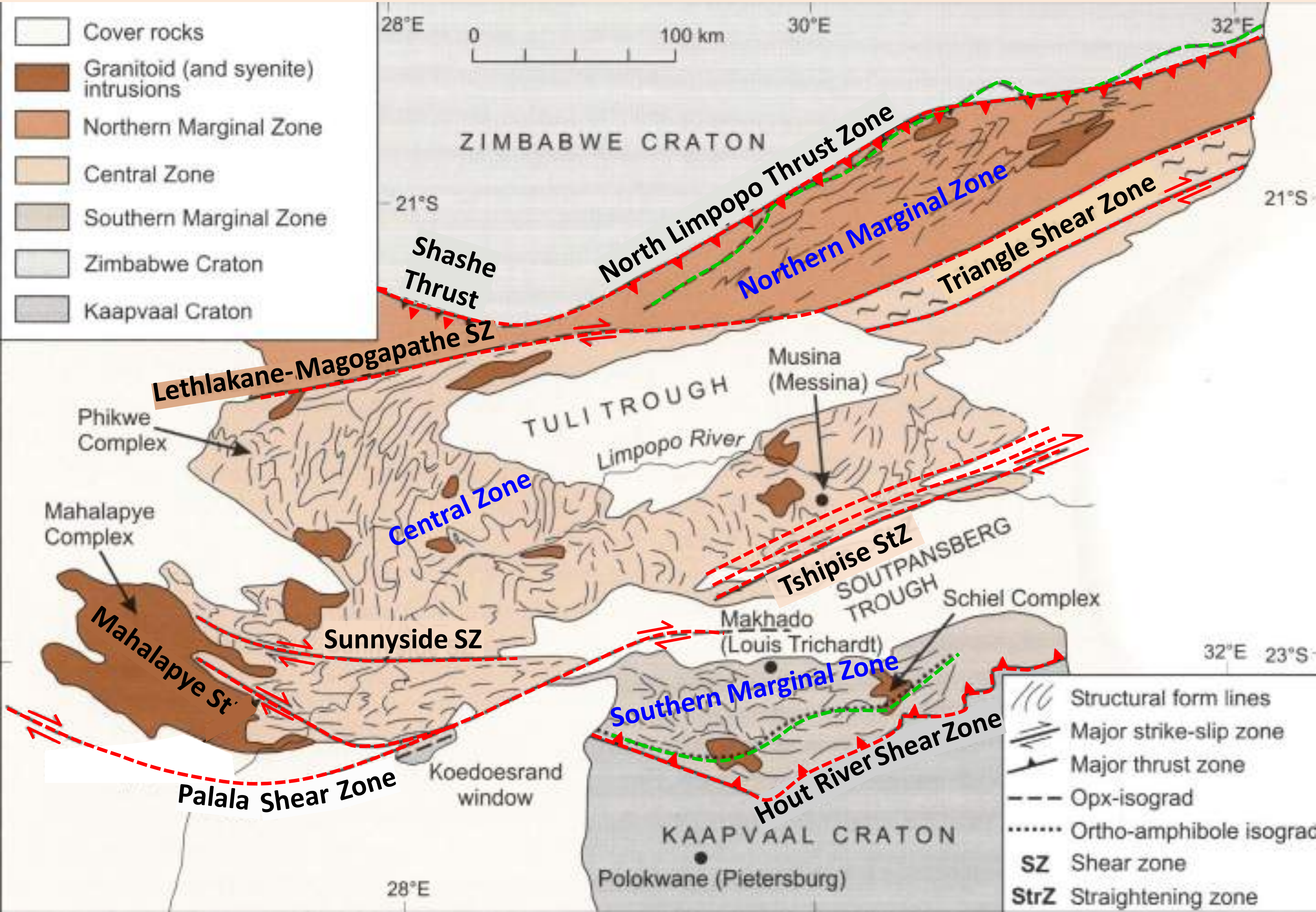
In the west to the ESE

In the center EW

In the east to ENE

Three zones: Northern Marginal Zone - Central Zone – Southern Marginal Zone all fault bounded

LIMPOPO BELT

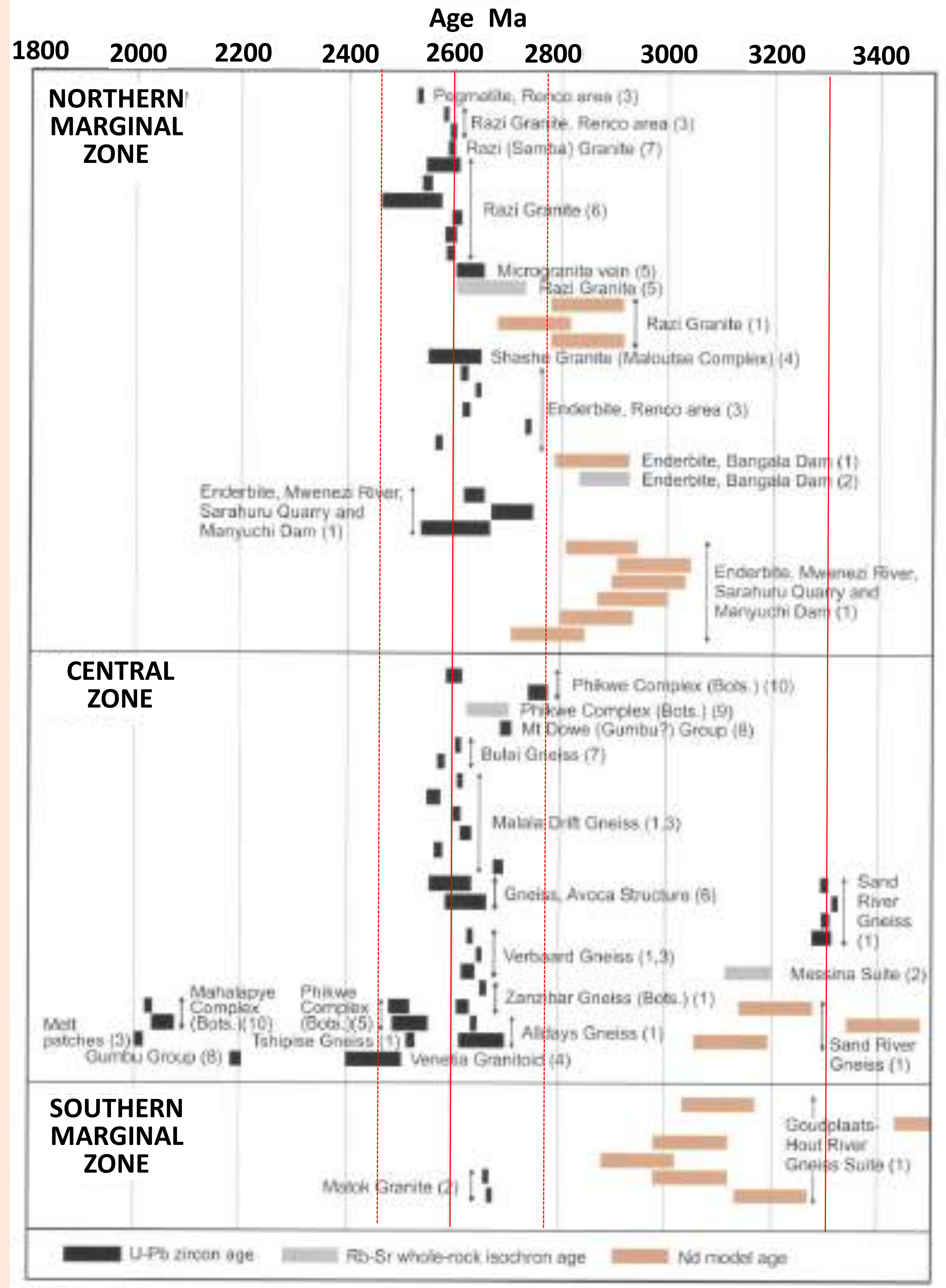


LIMPOPO BELT

ZIRCON DATES

Sand River Gneiss 3.3 Ga

Most other units 2.76 – 2.47 Ga



LIMPOPO BELT

METAMORPHIC DATES

NMZ & SMZ 2.6 – 2.4 Ga

Most other units 2.08 – 1.91 Ga

Older metamorphic events in NMZ and SMZ

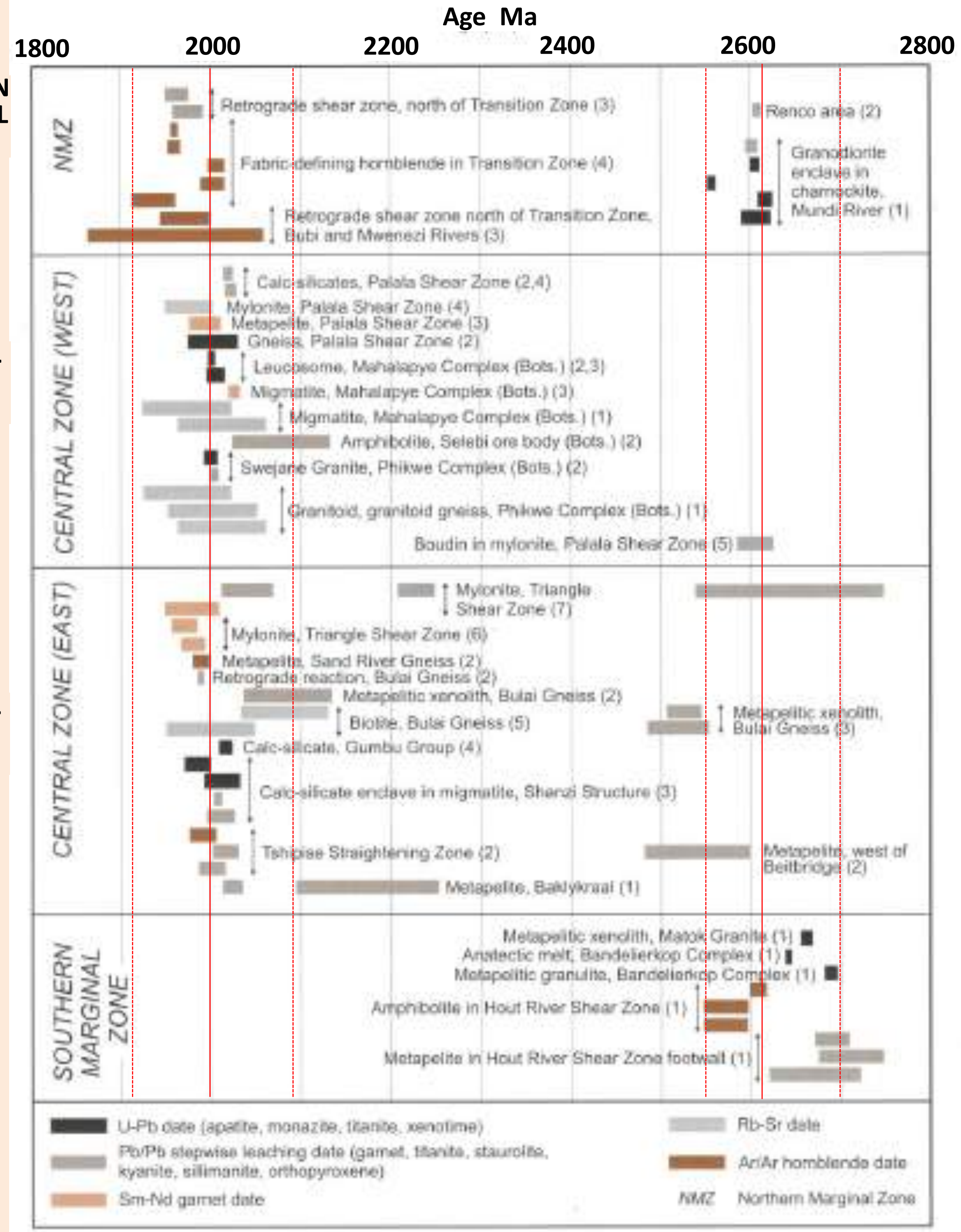
Very few in CZ

NORTHERN MARGINAL ZONE

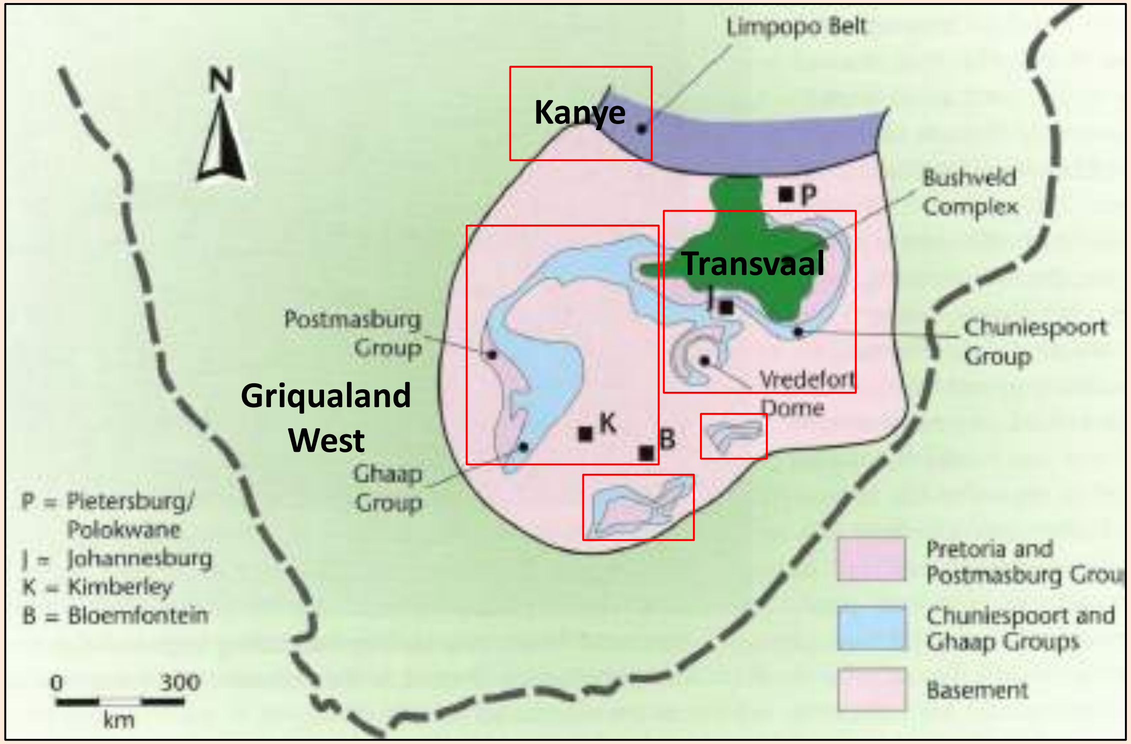
CENTRAL ZONE WEST

CENTRAL ZONE EAST

SOUTHERN MARGINAL ZONE



TRANSVAAL SUPERGROUP



TRANSVAAL SUPERGROUP

Three separate areas of outcrop around Tshwane, NW Cape and Botswana

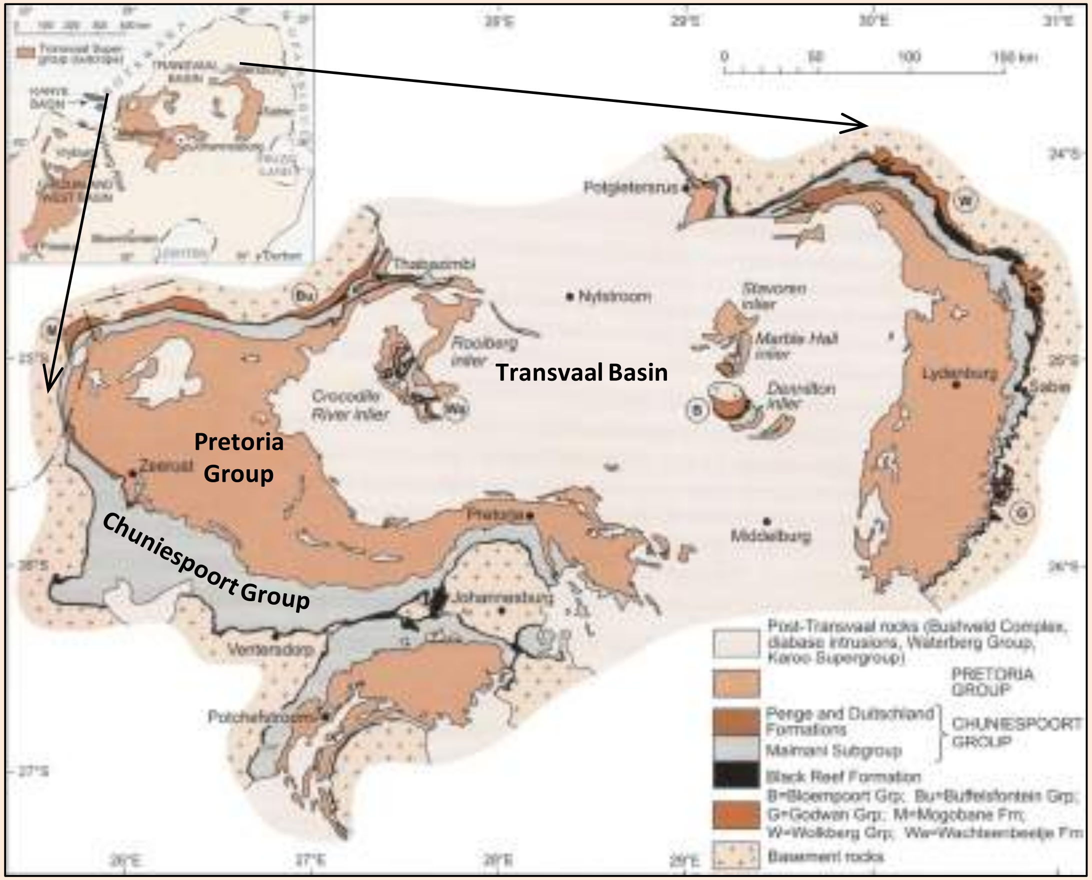
Kanye Group – little information

Precursor sediments/volcanics rocks (Black Reef, Wolkberg & others) 2,657-9 Ma

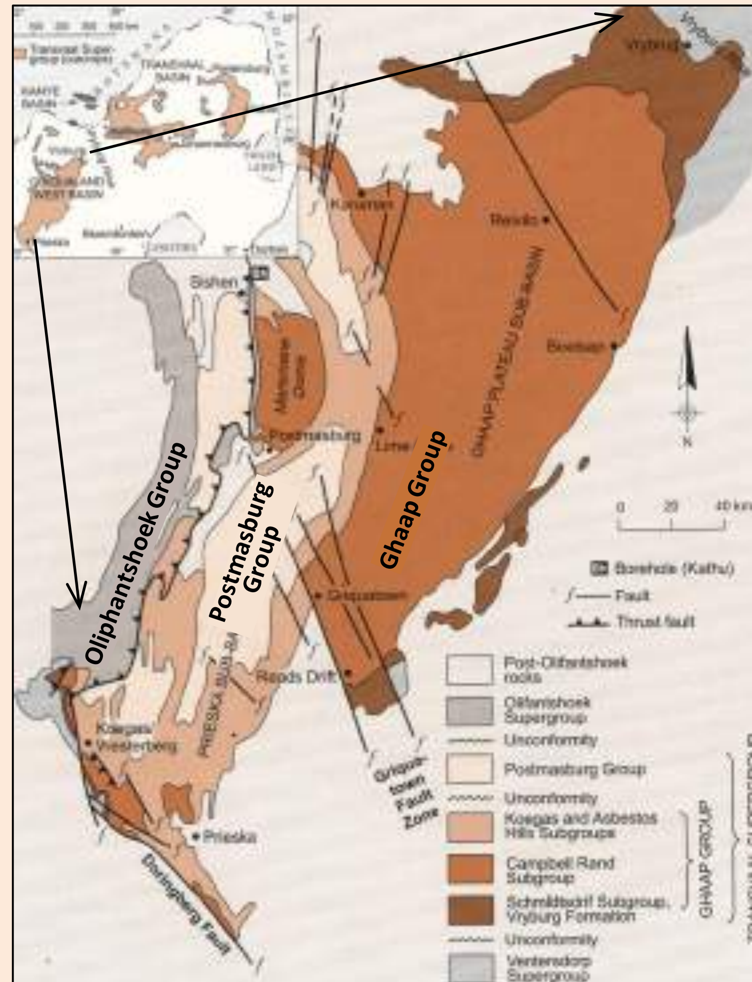
Extends intermittently on arcuate strike of ~1200 km

Bracketed between Ventersdorp lava ~2710 Ma and Bushveld at 2061 Ma (650 Ma)

BASIN	GRIQUALAND WEST	KANYE	TRANSVAAL	Lithology
Group	Oliphantshoek			Detrital Sediments
	Postmasburg	Segwagwa	Pretoria	Detrital Sediments
	Ghaap	Taupone	Chuniespoort	Chemical sediments



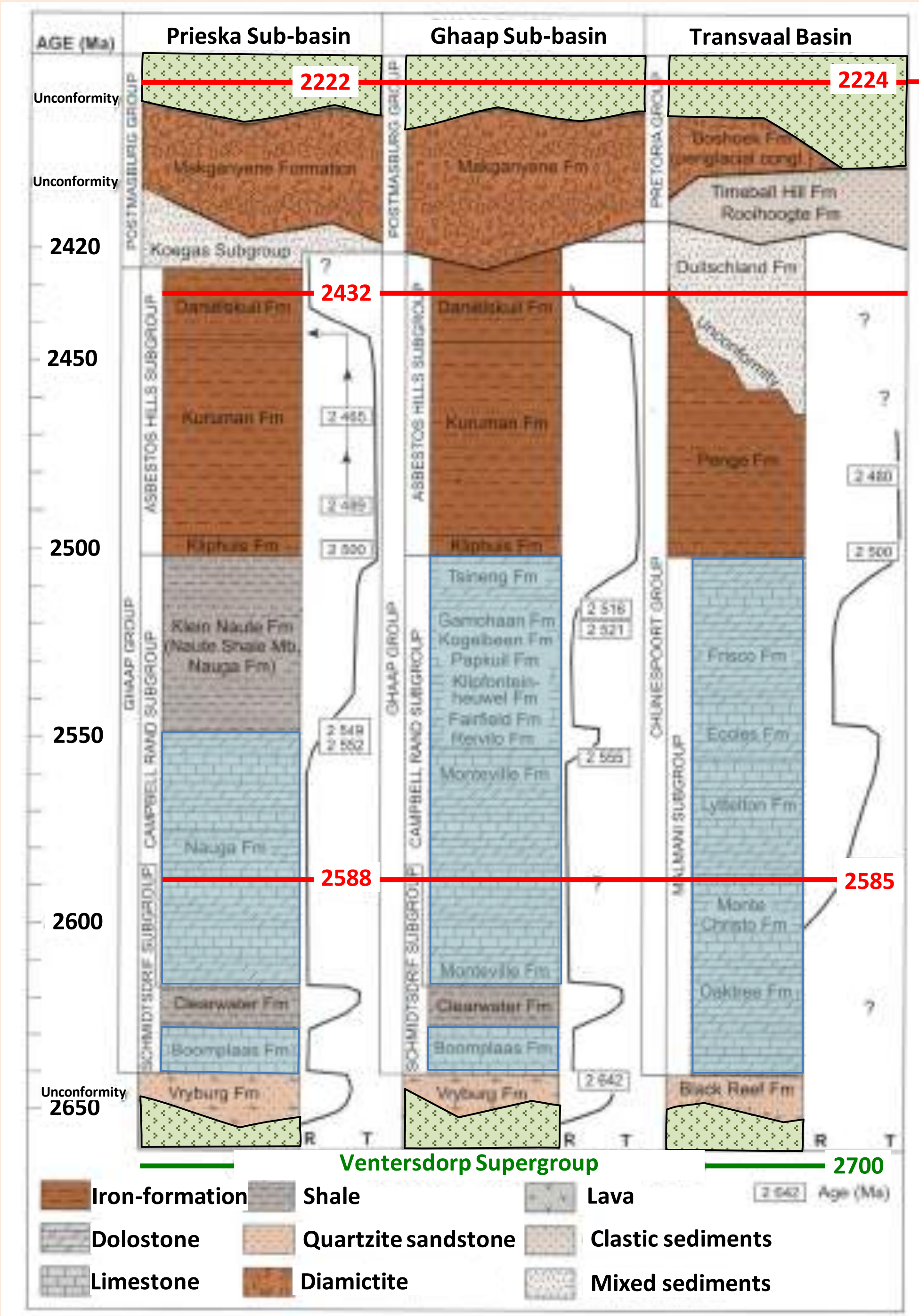
TRANSVAAL SUPERGROUP



Transvaal and Griqualand West Basins

Similar stratigraphy in lower chemical sediments between two andesitic units but more varied in upper clastic units

Griqualand West Basin deformed - several phases over 1.4 Ga



TRANSVAAL SUPERGROUP

Good correlation between main lithological units of Chuniespoort and Ghaap Groups

More variation between Pretoria and Postmasburg Groups except lower Formations

Upper Pretoria Group clastic sediments
Upper Postmasburg Group chemical sediments

Bracketed between Ventersdorp lava ~2710 Ma and Bushveld at 2061 Ma (650 Ma)

Correlations supported by age determinations – volcanic interlayers some not dated

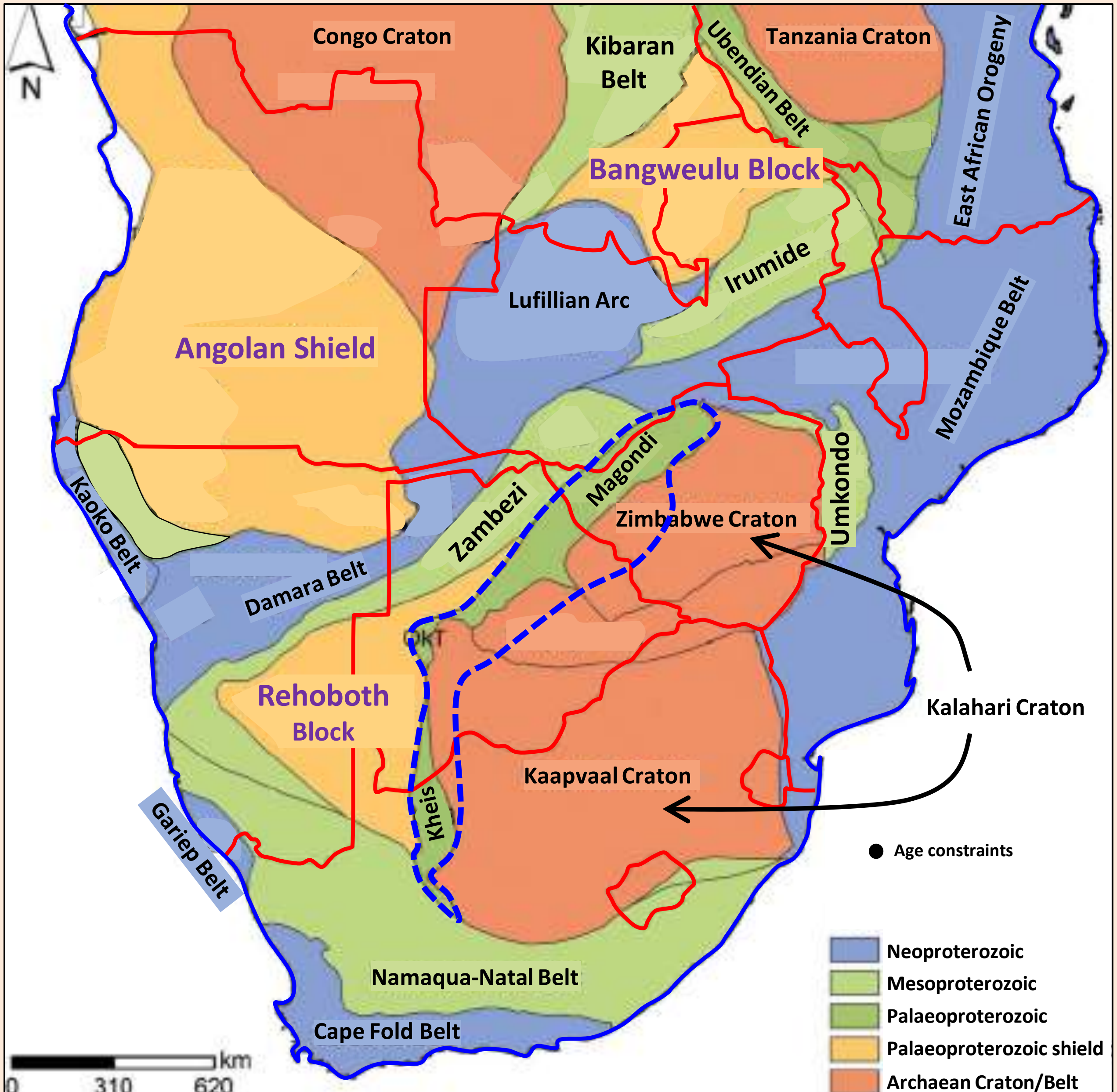
Many internal unconformities

Very thick dolomites much of it stromatolitic – the Great Oxygenation Event

Lifespan of basins ~ 500 Ma

MAGONDI OKWA KHEIS

AFRICAN OROGENIC EVENTS



PAN AFRICAN ~ 550 Ma

Cape Fold Belt
Gariep belt
Kaoko Belt
Mozambique Belt
Damara Belt
Lufillian Arc

Gondwana

KIBARAN ~ 1000 Ma

Kibaran Belt
Irumide Belt
Zambezi Belt
Namaqua-Natal Belt
Umkondo

Rodinia

UBENDIAN ~ 2000 Ma

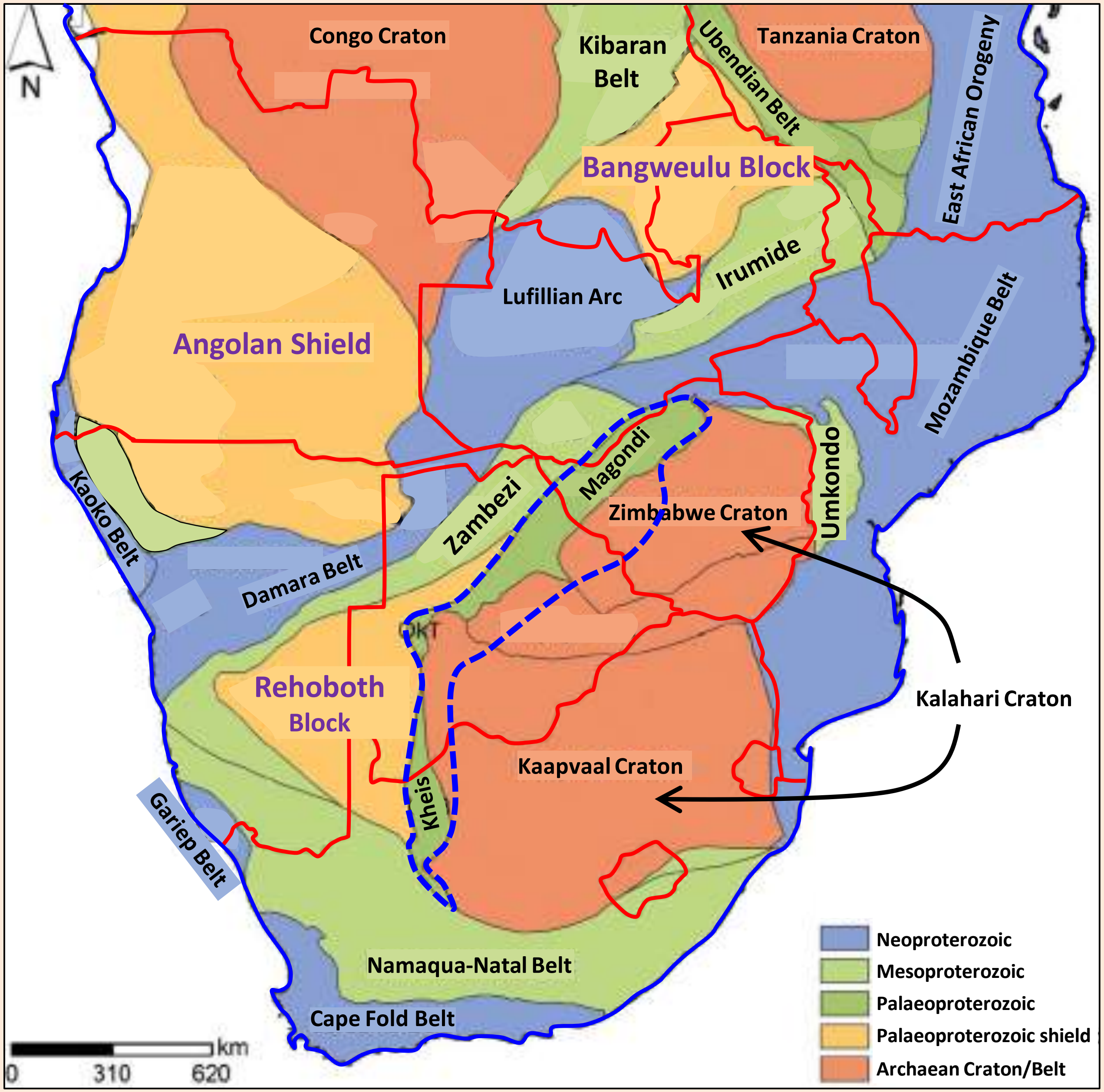
Ubendian Belt
Magondi-Kheis

Columbia

ARCHAEAN

BLOCKS/SHIELDS
Archaean/Palaeoproterozoic often under younger cover

MAGONDI OKWA KHEIS OROGENY



The Magondi part of break up of Columbia 2000 Ma

The Zambezi Orogenesis ~1000 Ma overprints Magondi break up of Rodinia

Pan African Orogenisis overprints Zambezi break up of Gondwana

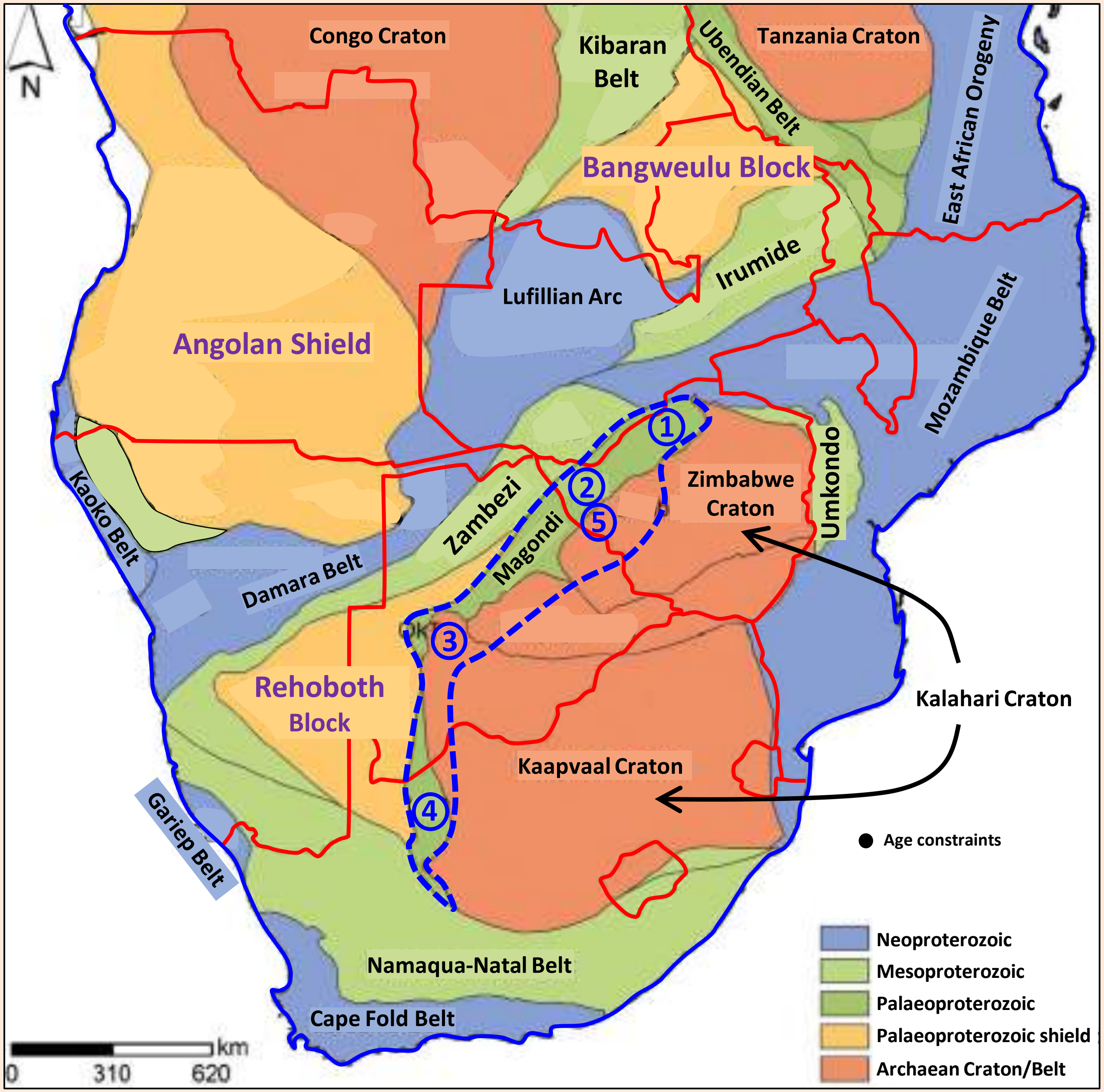
Sutures remain zones of weakness Pan African on Zambezi on Magondi

PAN AFRICAN ~ 550 Ma

KIBARAN ~ 1000 Ma

UBENDIAN ~ 2000 Ma

MAGONDI OKWA KHEIS OROGENY



Four correlated areas

1 Magondi Supergroup

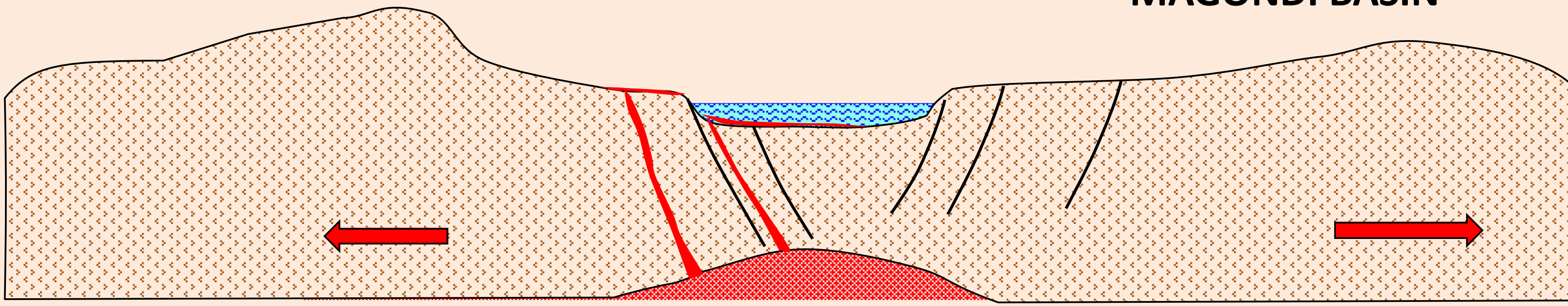
2 Kamativi Dete Inlier

3 Okwa Inlier

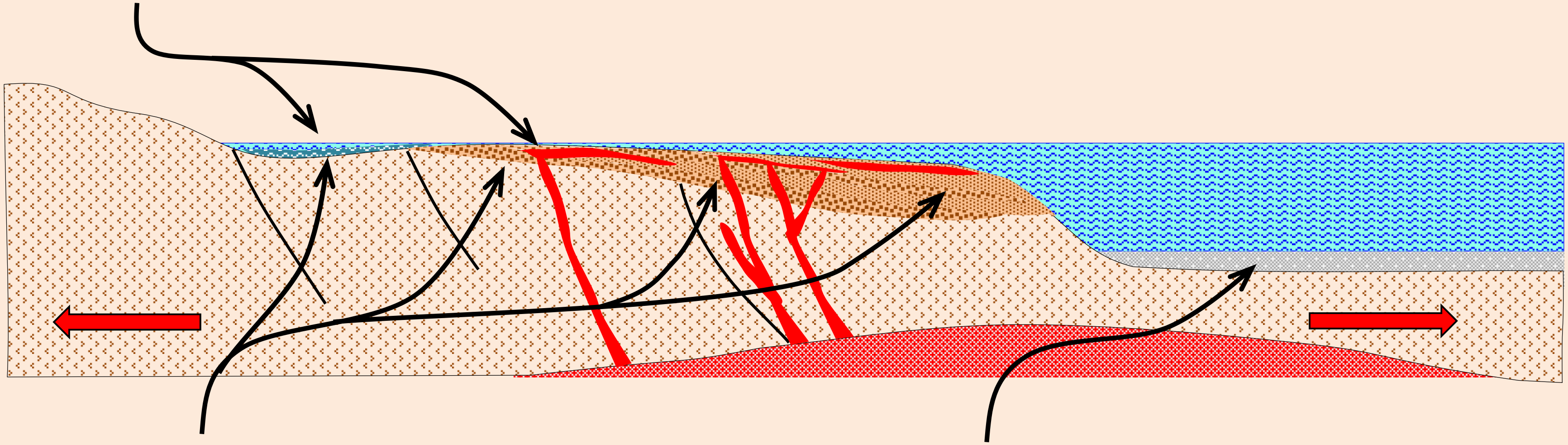
4 Kheis Belt

5 Insuza Borehole

MAGONDI BASIN



Deweras Group Clastic sediments lacustrine and aeolian with evaporites, basalt lava and pyroclastics in marginal rift setting

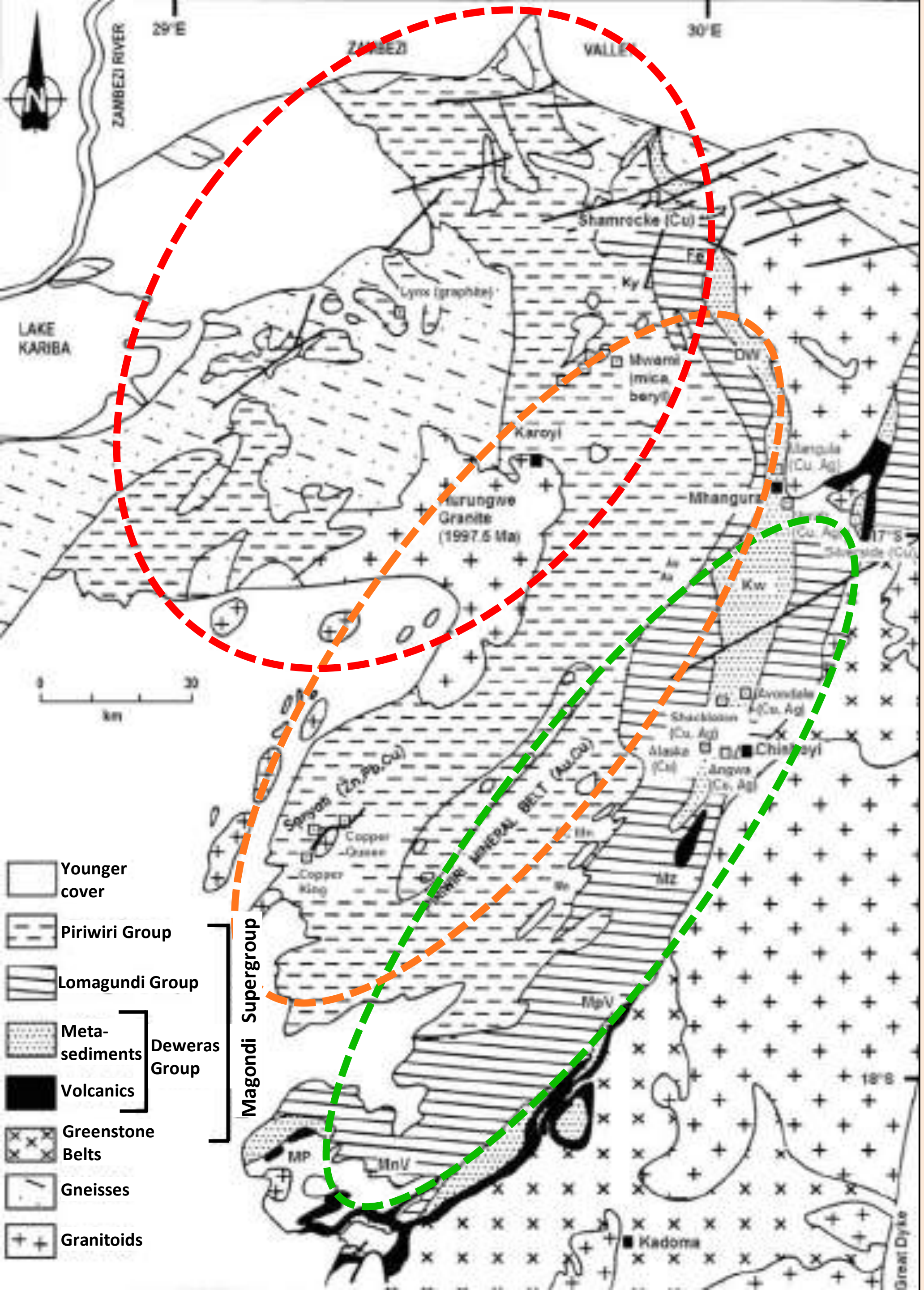


Lomagundi Group – Conglomerate, arkose, quartz arenite, stromatolitic dolomite, BIF, striped and graphitic slate, wackes, volcaniclastic rocks

Marginal marine and shallow storm-dominated shelf

Piriwiri Group - Phyllite, graphitic schist, chert, Mn beds, sulphides, lava, tuff and agglomerate

Deep marine, distal shelf, continental slope, submarine fan



MAGONDI OROGENY

DEWERAS GROUP
Volcano sedimentary rift deposits

LOMAGUNDI GROUP
Passive margin, back arc and foreland basin sedimentary successions

PIRIWIRI GROUP
Deeper water shelf to continental slope deposits

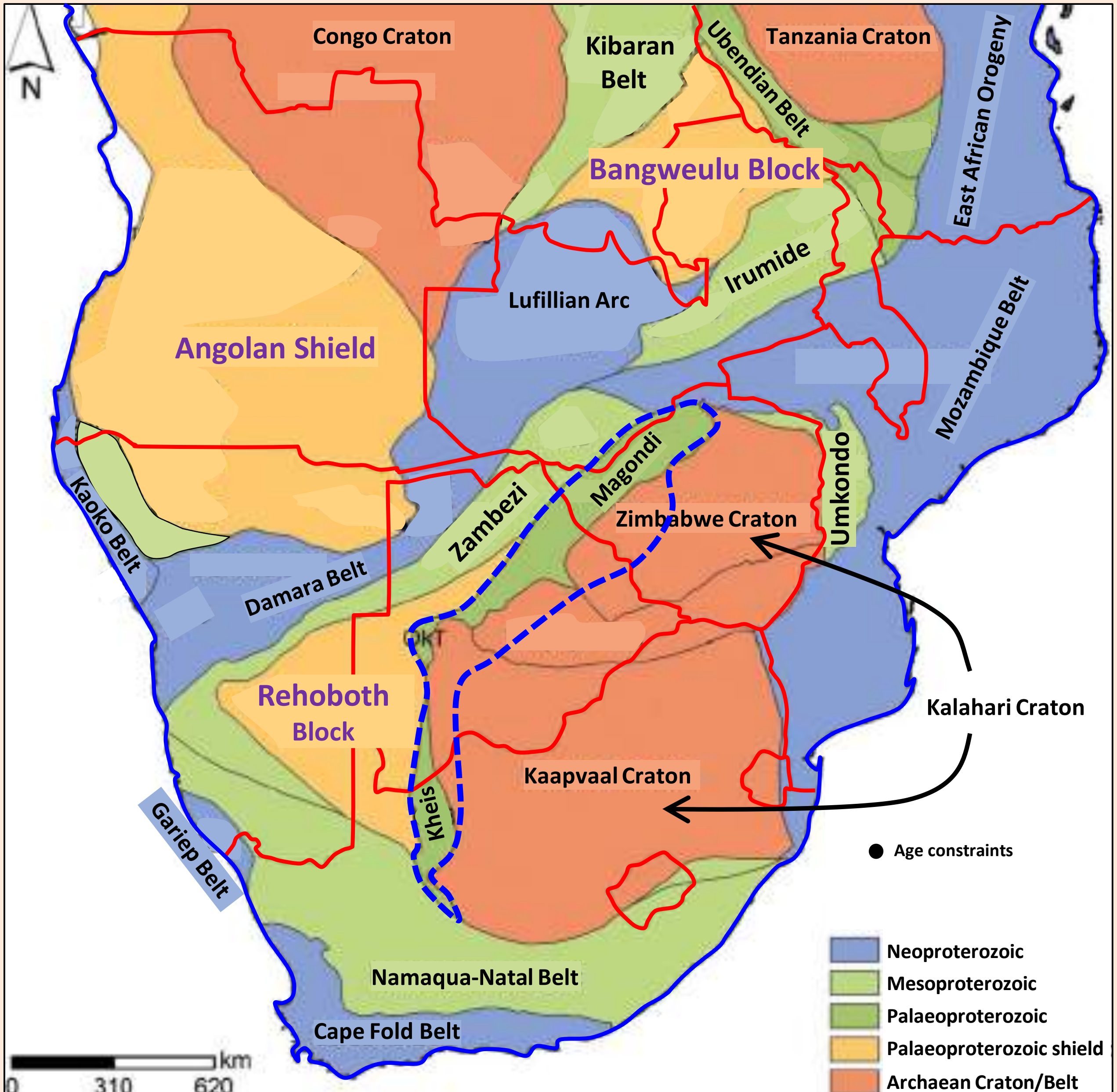
The Piriwiri Group distal, deeper-water time equivalent of the Lomagundi Group

Low-grade metamorphism in the southeast

Increases to upper greenschist and amphibolite grades to the north along strike and to the west

Granulite facies in the north west

MAGONDI OKWA KHEIS OROGENY



MAGONDI

DATES

Deweras rifting start 2.26 Ma but poorly constrained

Start of Magondi basin inversion and orogeny >2.0 Ga, also uncertain

Okwa Belt Botswana and Kheis Belt South Africa similar age and in part similar lithologies

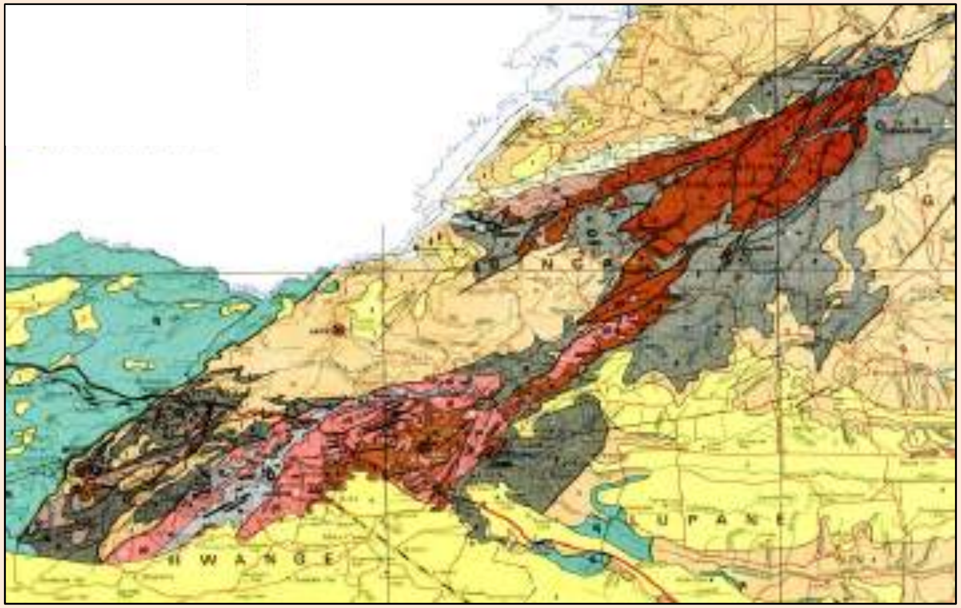
Gneisses & Quartzite six age determinations 1955 Ma – 2039 Ma

One date ~ 546 Ma reset by Pan African

Some older inherited dates of basement provenance

Munali Granite Zambia 1090 $\underline{+}$ 1 Ma Zambezi Belt overprints Magondi

MAGONDI OROGENY



KAMATIVI DETE INLIER

Metamorphism Upper Amphibolite/Granulite facies

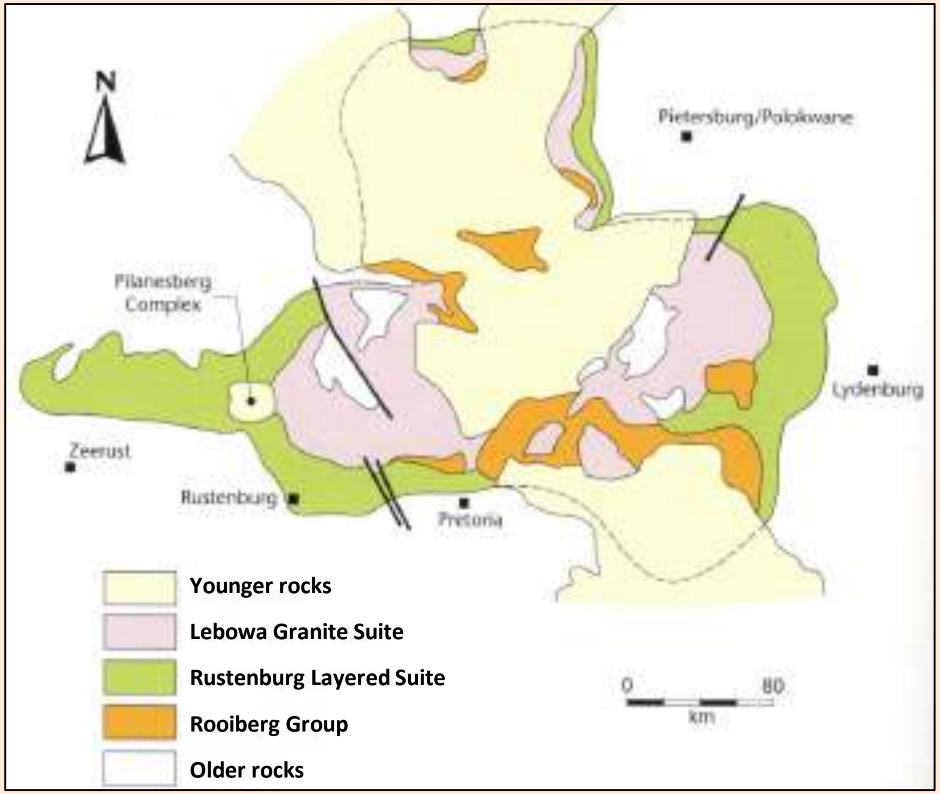
Dates

2.71 Ga metamorphosed Archaean basement

2.07 and 2.03 Intrusive biotite granites

Formation	Lithology	Correlation
	Intrusive Granites 2.07 – 2.03 Ga and pegmatites	
Kamativi	Muscovite and biotite schists and minor meta-sandstone	Piriwiri Group
Tshontanda	Garnet-mica schist, sillimanite gneisses, impure quartzites	Piriwiri Group
Inyantue	Garnetiferous gneisses, arenites, calcareous and graphitic rocks	Lomagundi and Deweras Groups
Malaputese	Pink arkosic meta-sandstone, calcsilicates, meta-argillites, meta-mafic volcanics, quartzites	Lomagundi and Deweras Groups
Migmatitic Granitic Orthogneiss 2.71 Ga		

BUSHVELD COMPLEX



400 by 300 km up to 8 km thick

Area 65,000 km^2

Age – 2,061 Ma

Individual layers up to 150 km strike

World's largest PGE Chromite Vanadium resources

Very large volume of associated felsic rocks

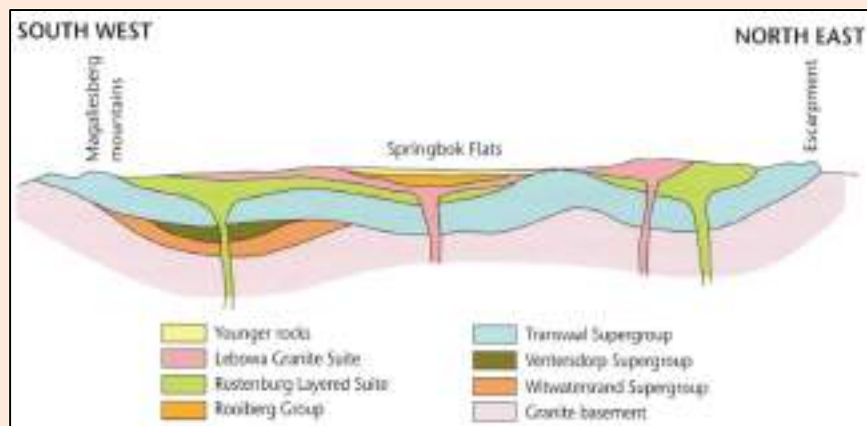
Intrusive into Transvaal Supergroup but generally tabular and conformable Transvaal sediments

Locally resting on Archaean basement

Lebowa Granite Suite – Last phase granite

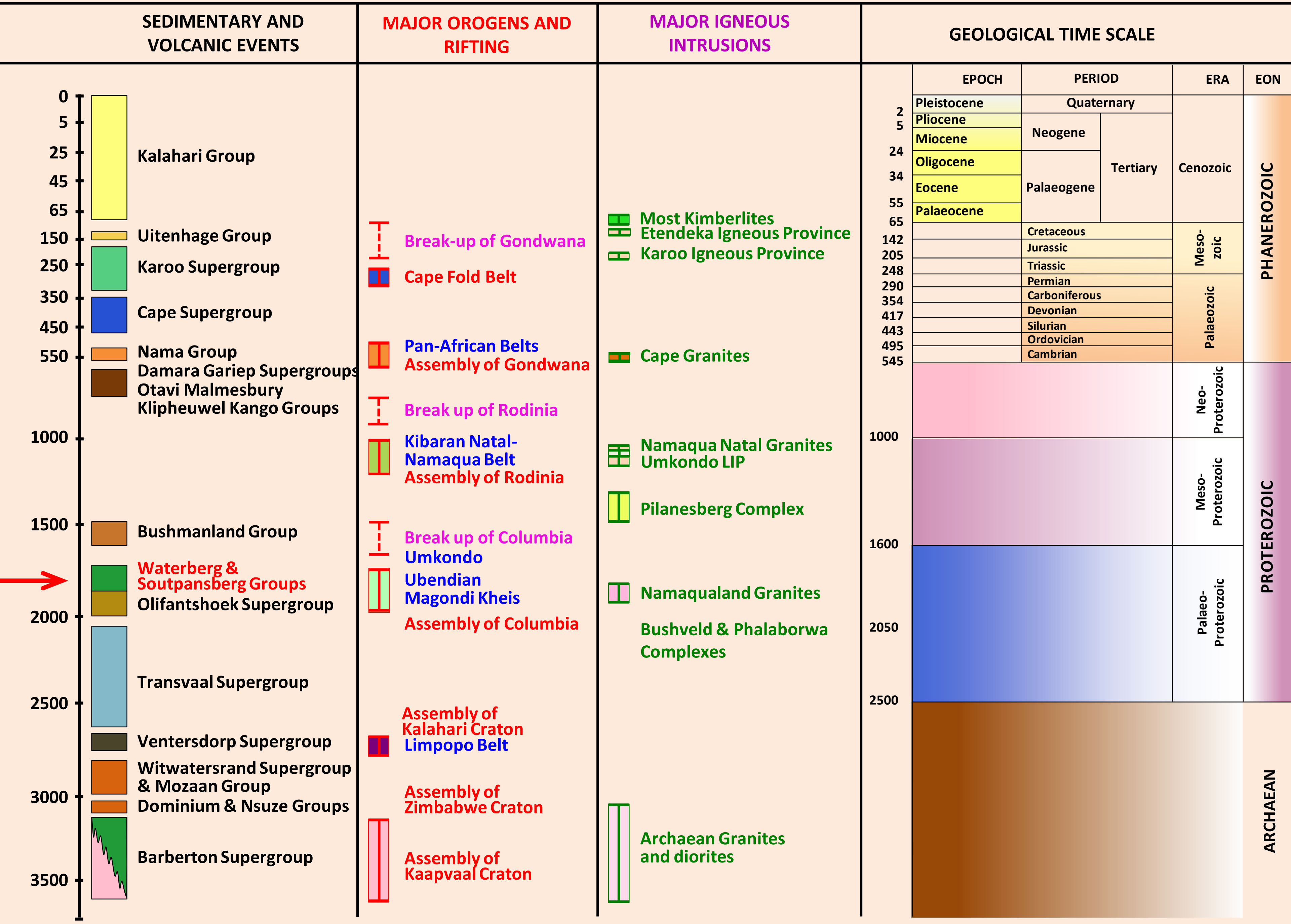
Rustenburg Layered Suite – Main intrusive phase

Rooiberg Group – Early extrusive phase

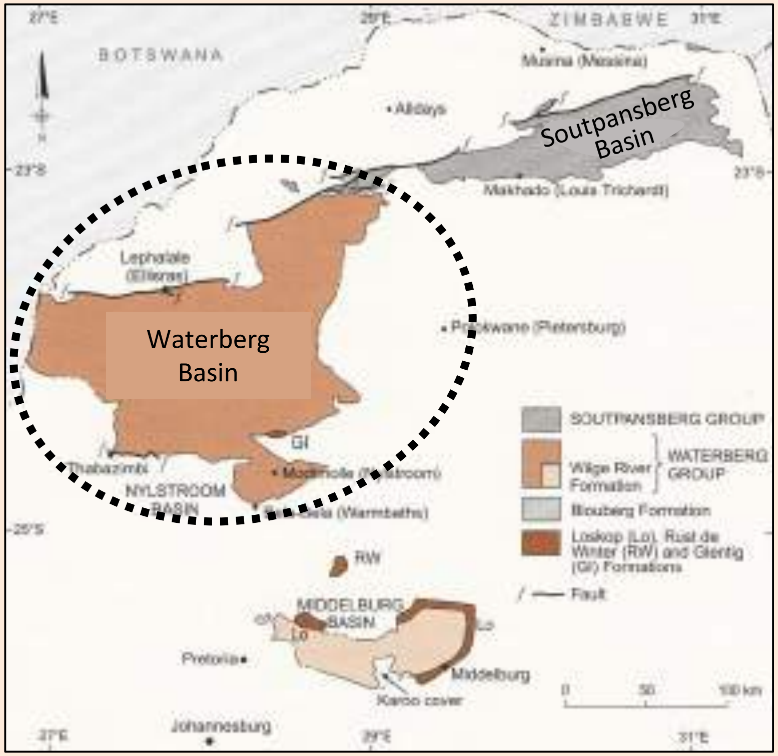


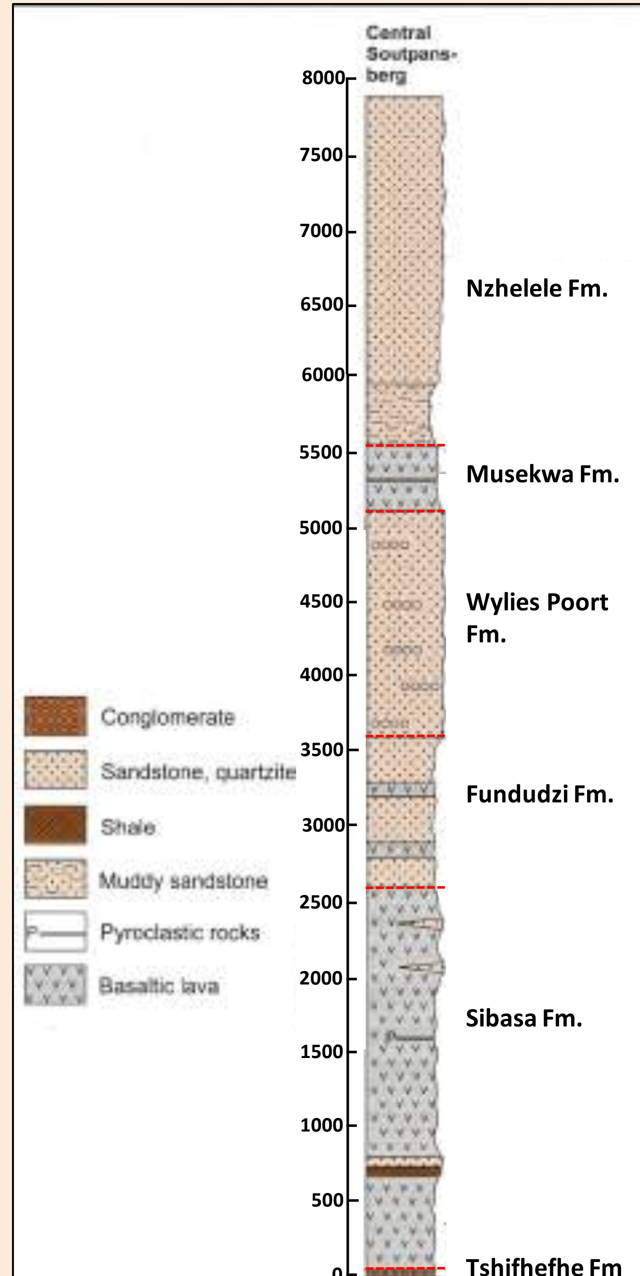
Zone	Rock	West m	East m	Markers	Olivine Fo	Opx Mg #	Plag An	Cpx	Mgt	Ap
UPPER ZONE	Apatite Diorite	1700	2000	17-21 Magnetite	5 35	30	7 40			
	Olivine Gabbronorite			8-14	43					
	Magnetite Gabbronorite			Main + 1-7		60				
	Gabbronorite	300	800	Pyroxenite		68-72	69-72			
MAIN ZONE						58-64	60			
	Gabbronorite	2800	1400							
				Mottled Anorthosites						
	Norite	300	800			75 80	75 78-80		Chr	
CRITICAL ZONE	Norite	520	1000	Merensky UG MG	77-81 81-83	79-83	78-80			
	Pyroxenite	780	800	LG 1-6		81-85				
LOWER ZONE	Harzburgite	300	500		83-89	83-89				
	Pyroxenite	520	800		85					
MARGINAL ZONE										

WATERBERG AND SOUTPANSBERG


SEDIMENTARY AND VOLCANIC EVENTS
MAJOR OROGENS AND RIFTING
MAJOR IGNEOUS INTRUSIONS
GEOLOGICAL TIME SCALE
0
5
25
45
65
150
250
350
450
550
1000
1500
2000
2500
3000
3500
Kalahari Group
Uitenhage Group
Karoo Supergroup
Cape Supergroup
Nama Group
Damara Gariep Supergroups
Otavi Malmesbury
Klipheuwel Kango Groups
Bushmanland Group
Waterberg &
Soutpansberg Groups
Olifantshoek Supergroup
Transvaal Supergroup
Ventersdorp Supergroup
Witwatersrand Supergroup
& Mozaan Group
Dominium & Nsuze Groups
Barberton Supergroup
Break-up of Gondwana
Cape Fold Belt
Pan-African Belts
Assembly of Gondwana
Break up of Rodinia
Kibaran Natal-
Namaqua Belt
Assembly of Rodinia
Break up of Columbia
Umkondo
Ubendian
Magondi Kheis
Assembly of Columbia
Assembly of
Kalahari Craton
Limpopo Belt
Assembly of
Zimbabwe Craton
Assembly of
Kaapvaal Craton
Most Kimberlites
Etendeka Igneous Province
Karoo Igneous Province
Cape Granites
Namaqua Natal Granites
Umkondo LIP
Pilanesberg Complex
Namaqualand Granites
Bushveld & Phalaborwa
Complexes
Archaean Granites
and diorites
EPOCH
PERIOD
ERA
EON
Pleistocene
Quaternary
2
Pliocene
5
Miocene
Neogene
24
Oligocene
Tertiary
Cenozoic
34
Eocene
Palaeogene
55
Palaeocene
65
Cretaceous
142
Jurassic
Meso-
zoic
205
Triassic
248
Permian
290
Carboniferous
354
Devonian
417
Silurian
Palaeozoic
443
Ordovician
495
Cambrian
545
PHANEROZOIC
Neo-
Proterozoic
1000
Meso-
Proterozoic
1600
Palaeo-
Proterozoic
PROTEROZOIC
2050
2500
ARCHAEAN

SOUTPANSBERG GROUP





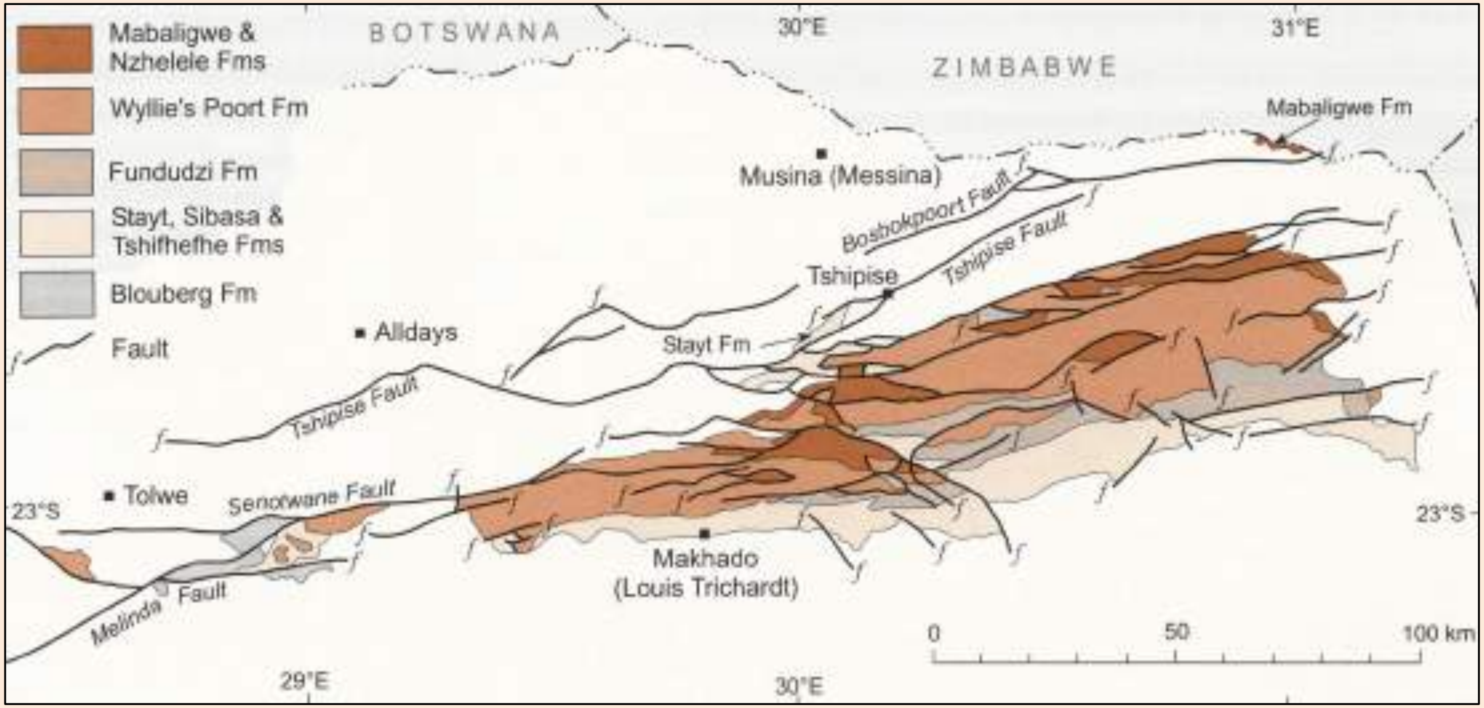
SOUTPANSBERG GENERALISED STRATIGRAPHY

7800 m maximum thickness ~ 1974 - 1800 Ma

Basalt (2500 m) overlain by quartz arenites (4500 m) interlayered with basalt units (total 600m), minor conglomerate & shale

Dips 30° NNW

WATERBERG AND SOUTPANSBERG GROUPS



SOUTPANSBERG DEPOSITIONAL ENVIRONMENT

Much debated and no consensus

Current shape controlled by Limpopo tectonics

No proximal sedimentary rocks only distal

Both basins could have formed by thermal subsidence following Bushveld magmatism

NAMAQUA NATAL BELT

NAMAQUA NATAL BELT

PAN AFRICAN 550 Ma

Saldania Belt
Cape Fold Belt
Gariep belt
Kaoko Belt
Mozambique Belt
Damara Belt
Lufillian Arc

KIBARAN 1000 Ma

Kibaran Belt
Irumide Belt
Zambezi Belt
Namaqua-Natal Belt
Umkondo

UBENDIAN 2000 Ma

Ubendian Belt
Magondi-Kheis

LIMPOPO 2750 Ma

BLOCKS/SHIELDS
Archaean/Palaeoproterozoic often under younger cover

NAMAQUA–NATAL PROVINCE

EXTENT

Mostly under younger cover – Karoo

Two sectors

Namaqua

Natal

KIBARAN 1000 Ma

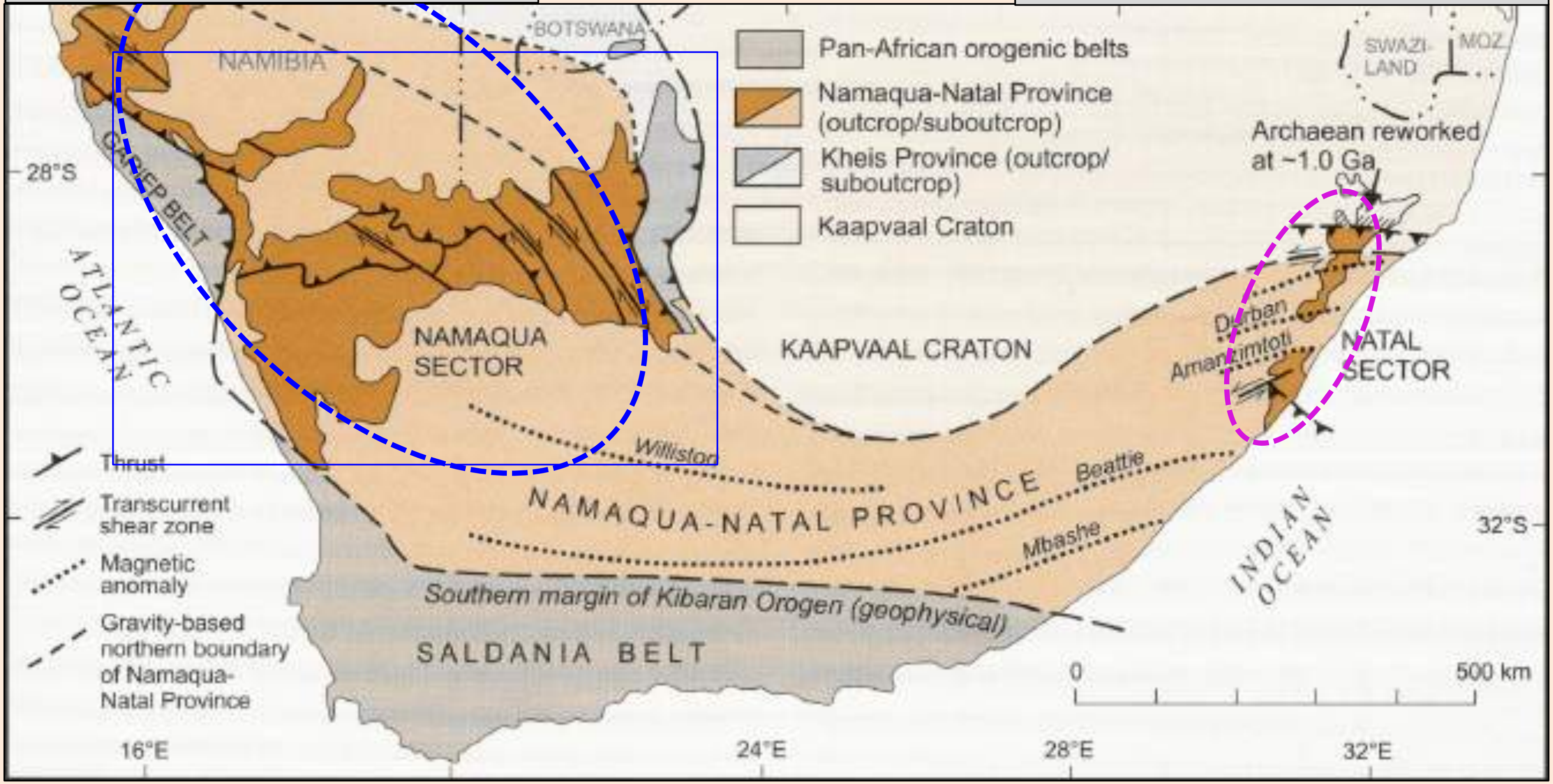
AGE

1010 Ma last deformation

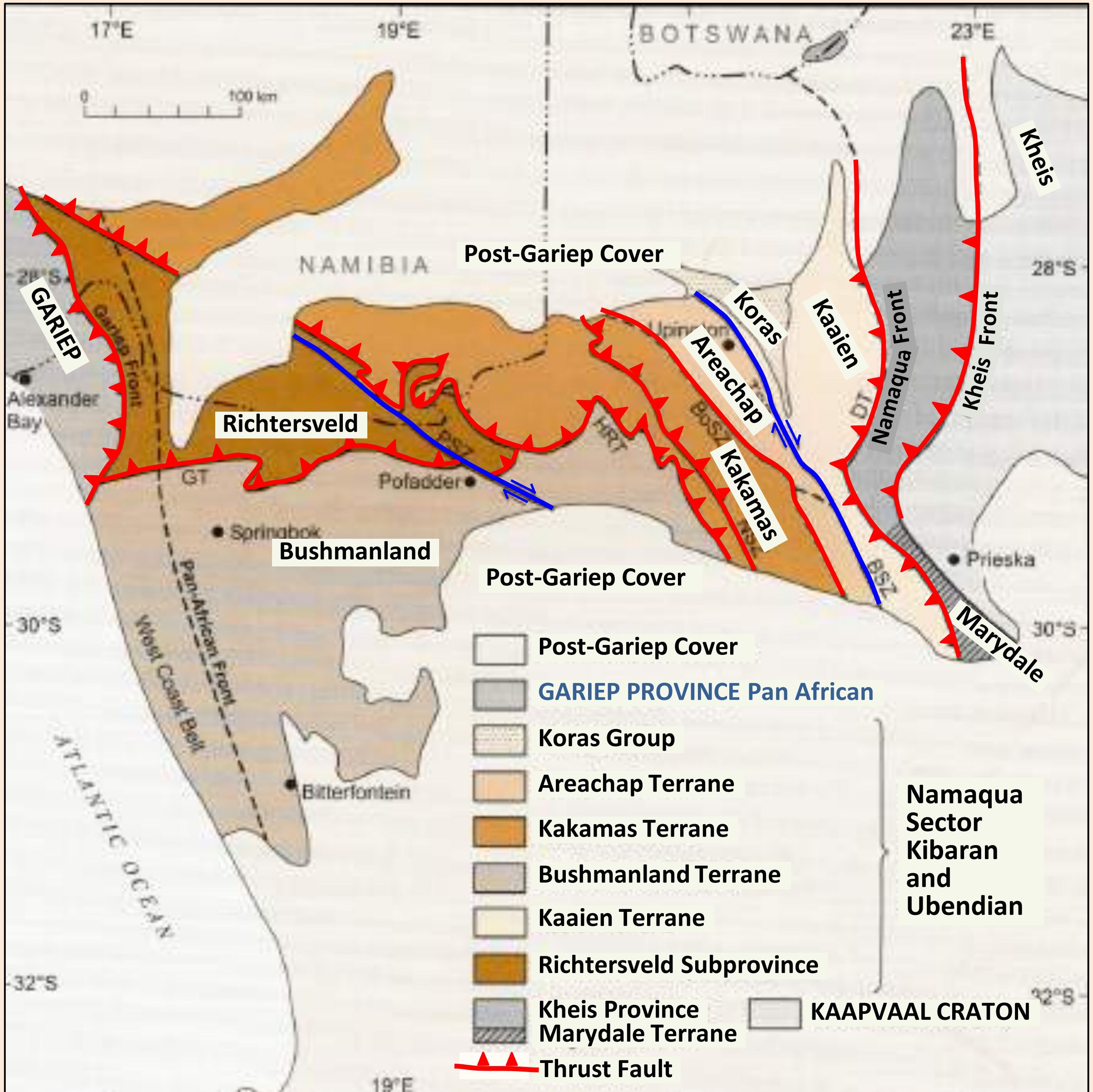
1210 Ma start of collision

~ 1300 Subduction

~ 1360 Rifting



NAMAQUA–NATAL PROVINCE



NAMAQUA SECTOR

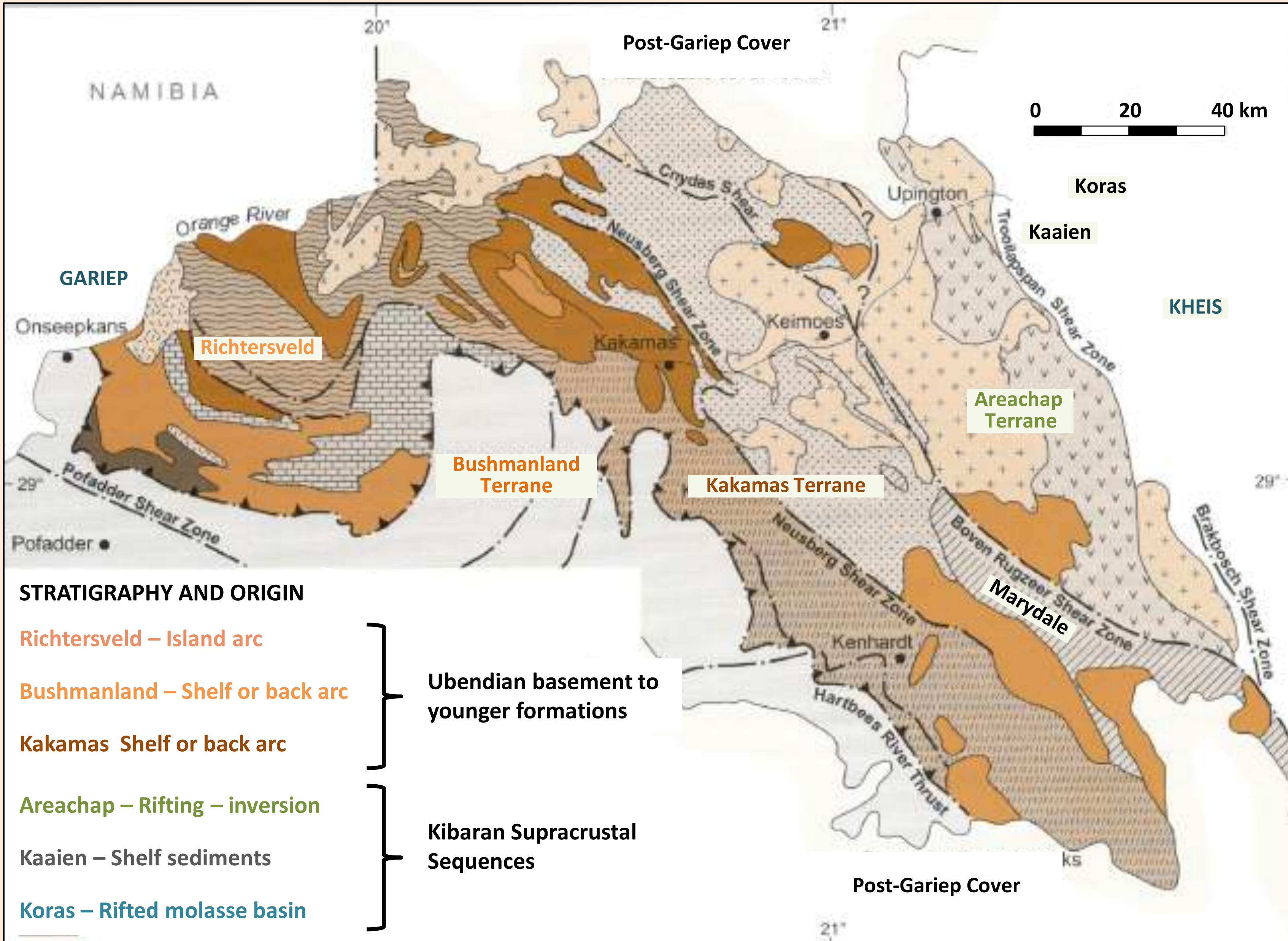
- Areachap
- Kaaien
- Koras

} KIBARAN ~ 1000 Ma

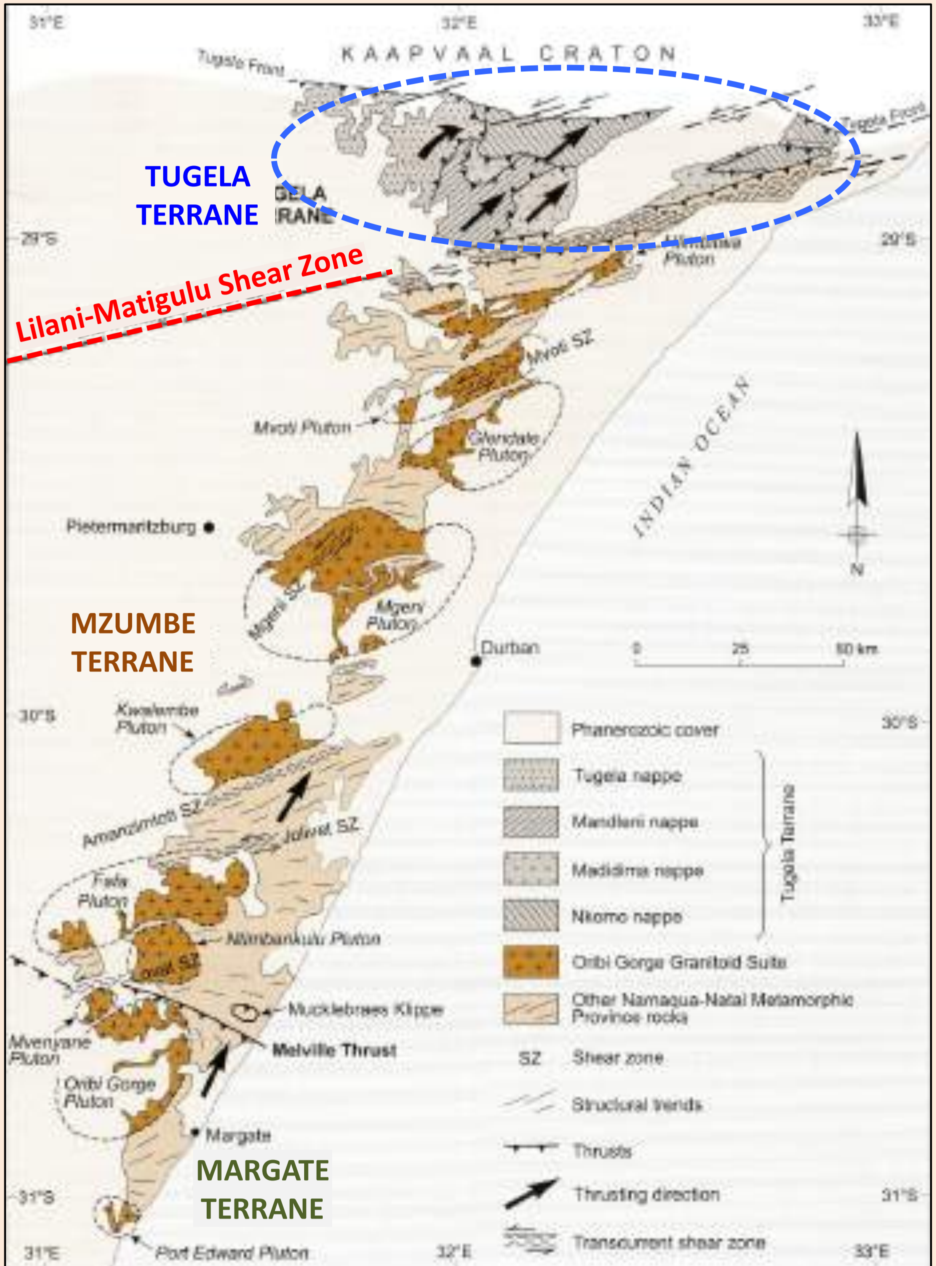
- Richtersveld
- Bushmanland
- Kakamas

} UBENDIAN ~ 2000 Ma

NAMAQUA–NATAL PROVINCE



NAMAQUA–NATAL PROVINCE



NATAL SECTOR TERRANES

TUGELA TERRANE ~ 1209 – 1155 Ma ~ 5 km

Natal Sector thrust front/allochthonous

Ntingwe Group ~ 300 m
Passive margin sediments unconformable on craton (very low greenschist)

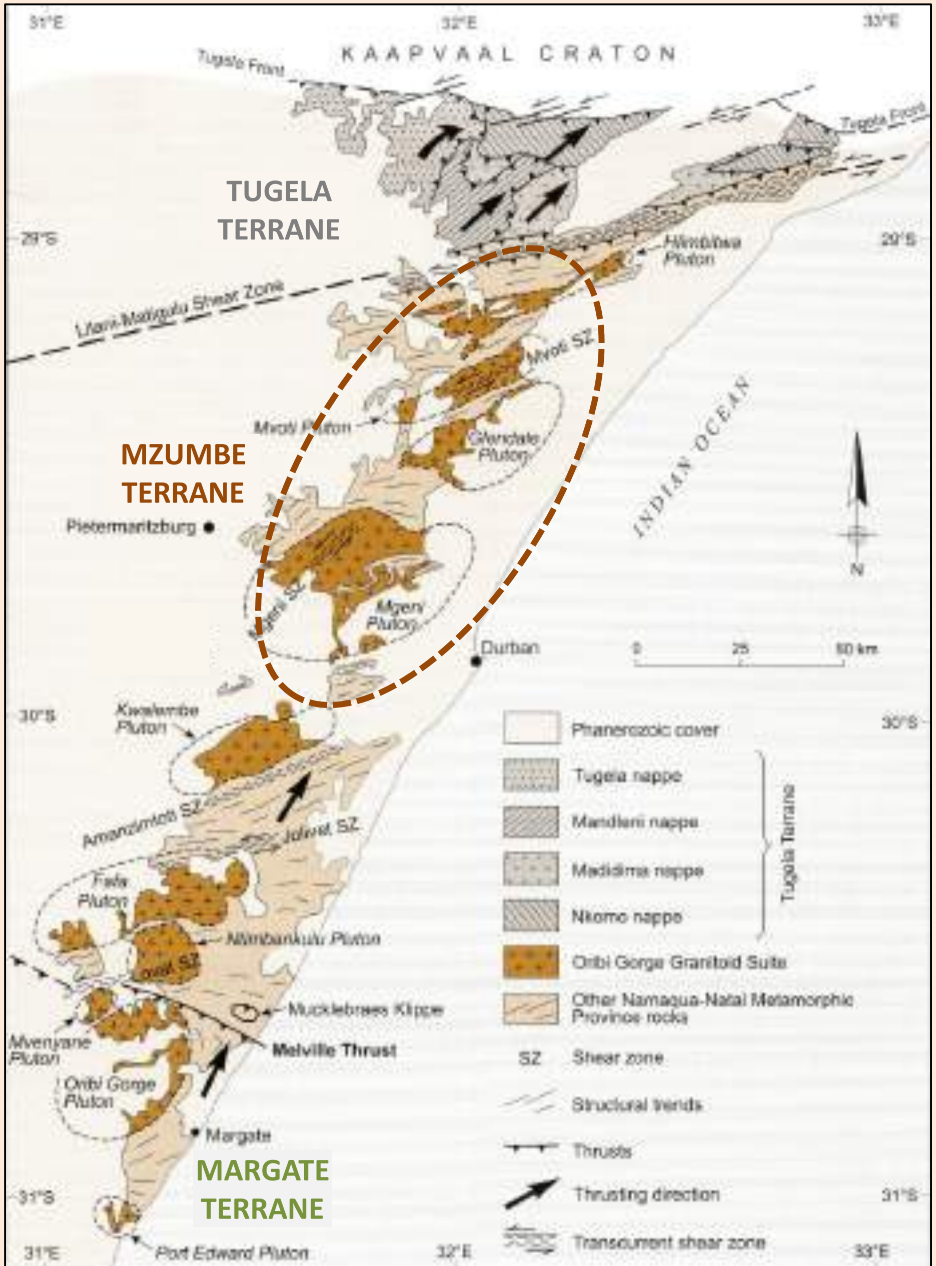
Structurally overlain by

Mfongosi Group
Pillowed basalt upper part of an ophiolite

Tugela Group
Nappe fold/thrust structures
layered mafic/ultramafic bodies and granitoids (arc-type calc-alkaline)
oceanic (?) plagio-granite

Lilani Matigulu Shear Zone vertical transform fault marks south margin of Tugela Terrane

NAMAQUA–NATAL PROVINCE



NATAL SECTOR TERRANES

MZUMBE TERRANE ~ 1235 Ma
P/T 700° and 5 – 6 kb

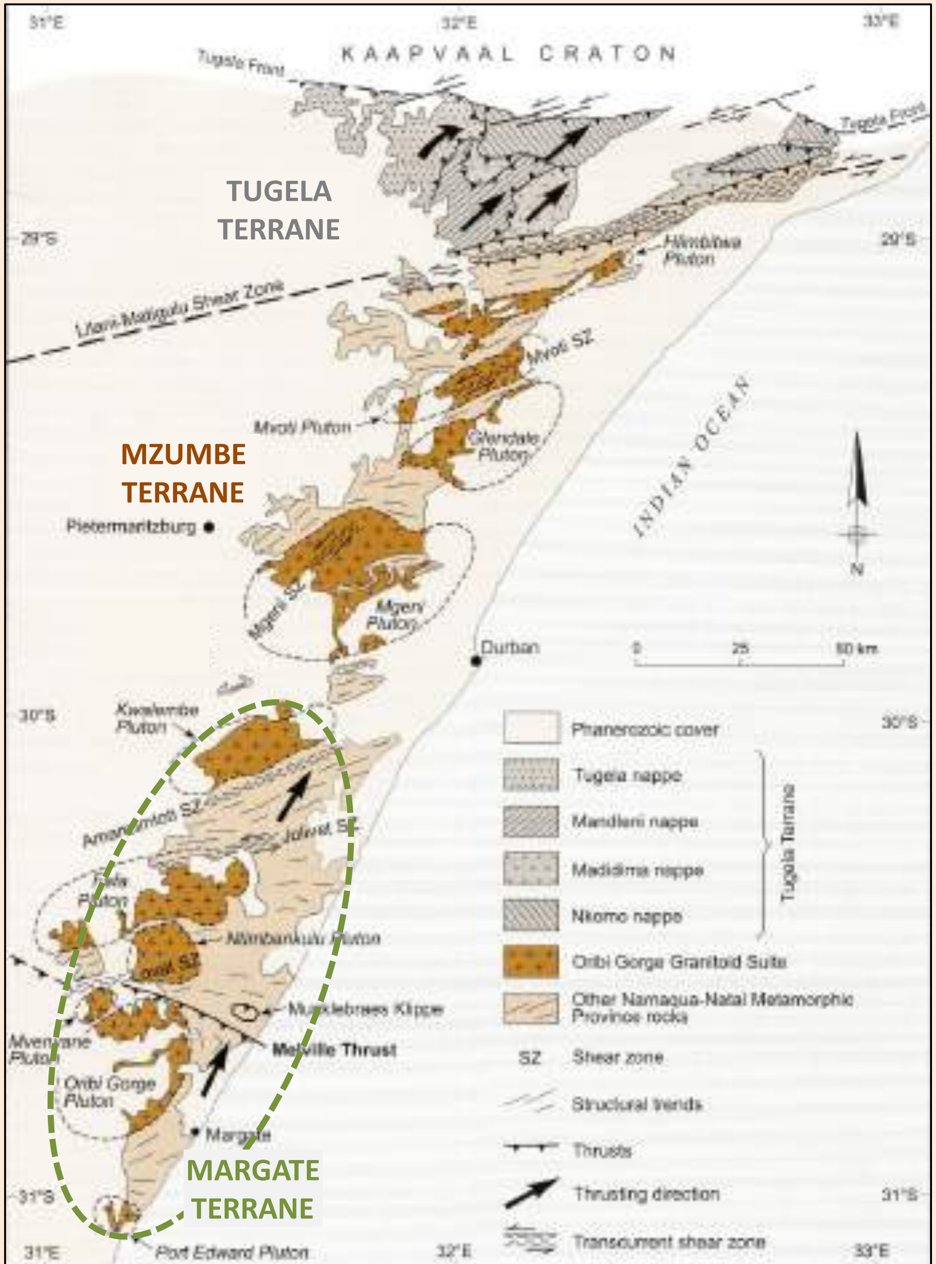
North margin Lilani Matigulu Shear Zone

Amphibolite grade supracrustal gneiss intruded by pre- syn- and late-tectonic granitoids

Basalt/andesite with minor sediments interpreted as island arc

Large volume of intrusives indicates deeper level of an arc

NAMAQUA–NATAL PROVINCE



NATAL SECTOR TERRANES

MARGATE TERRANE ~ 1235 Ma
P/T 1000° and 5 kb

Mzimkulu Group

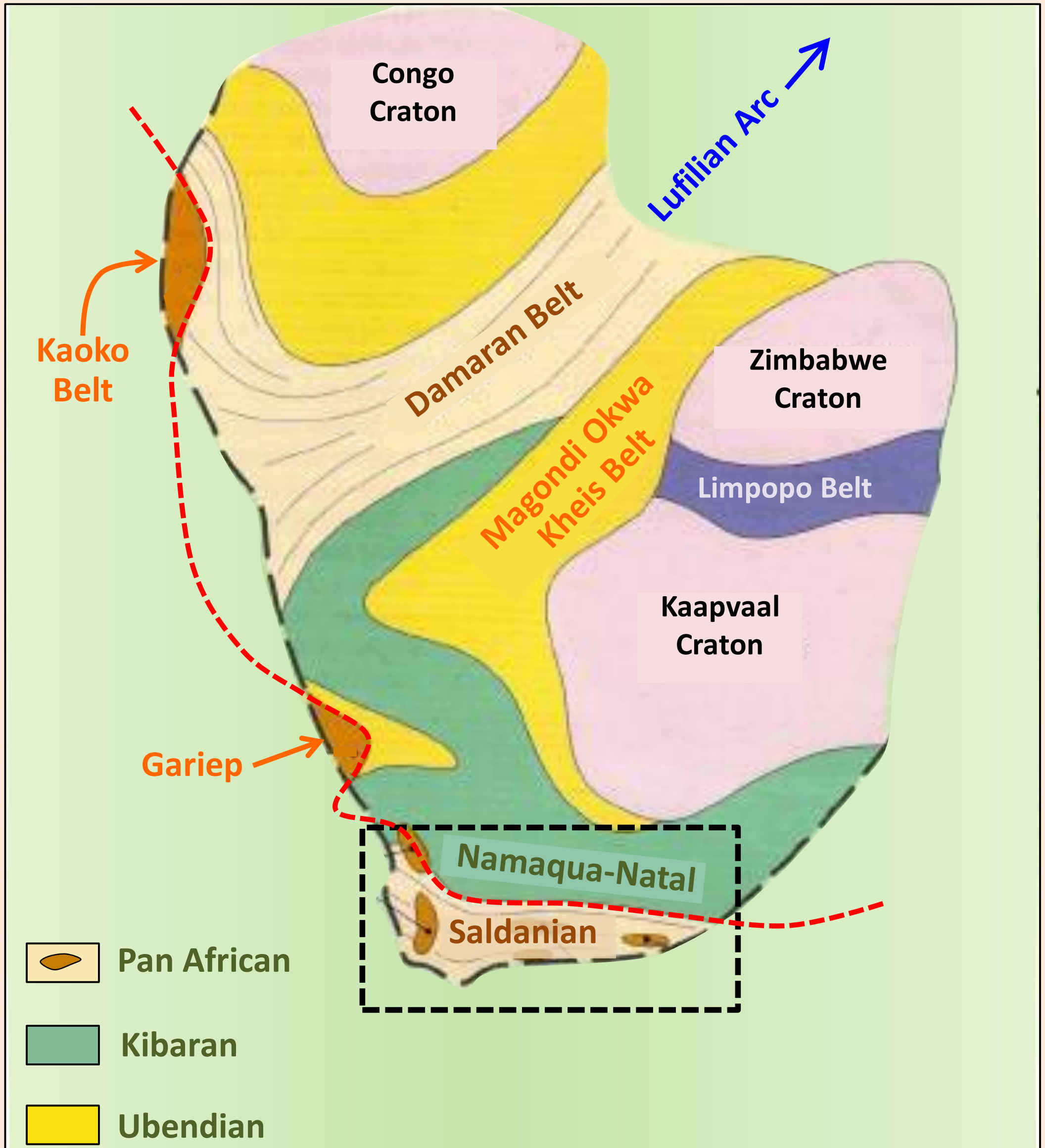
Thin slices of granulite facies marble/quartzite/amphibolite

Paragneiss derived from argillites and calc-silicates

Two-pyroxene granulites/enderbites

Various intrusive granitoids and pegmatites anatectic melts

CAPE SUPERGROUP



PRE-CAPE BASEMENT
PAN AFRICAN
SALDANIAN

KAOKO & GARIEP GROUPS

Forearc / trench / foreland basin / shallow & distal sediments / minor ophiolite / molasse

Shallow marine sandstones shale limestones

SALDANIAN

BOLAND TERRANE

SWARTLAND TERRANE

TYGERBERG TERRANE

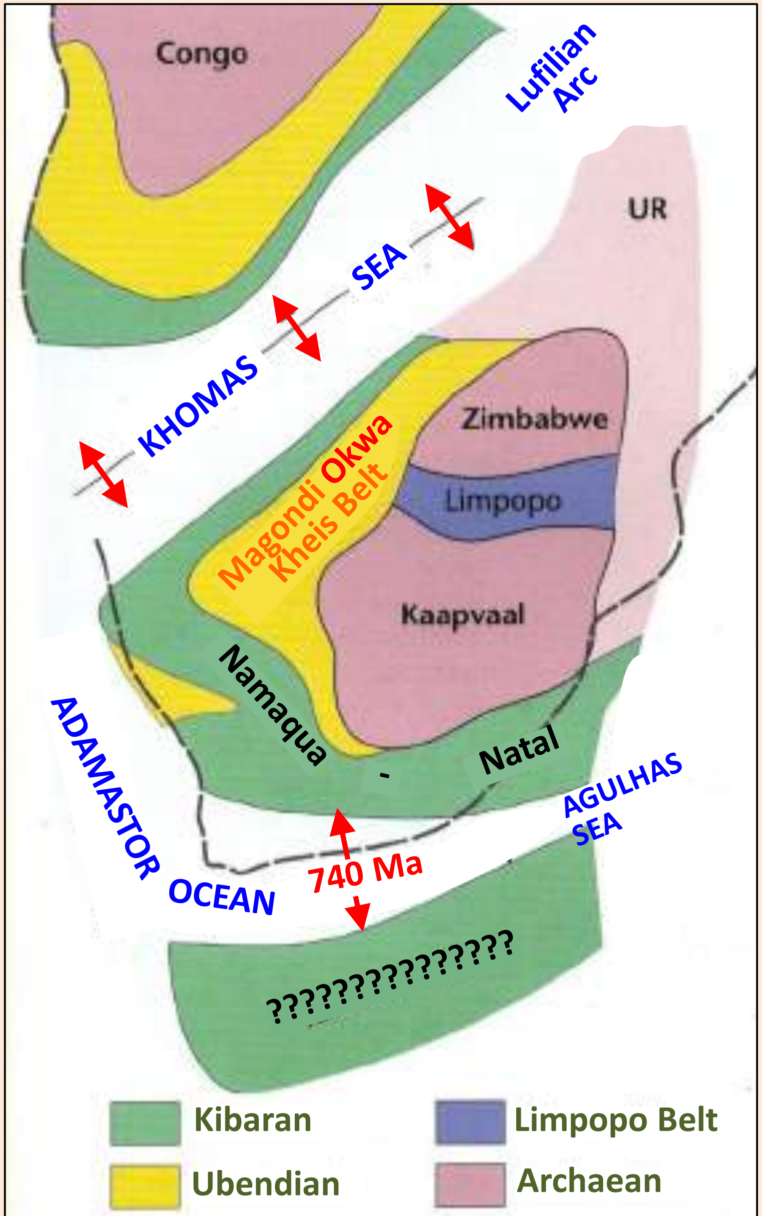
KANGO INLIER

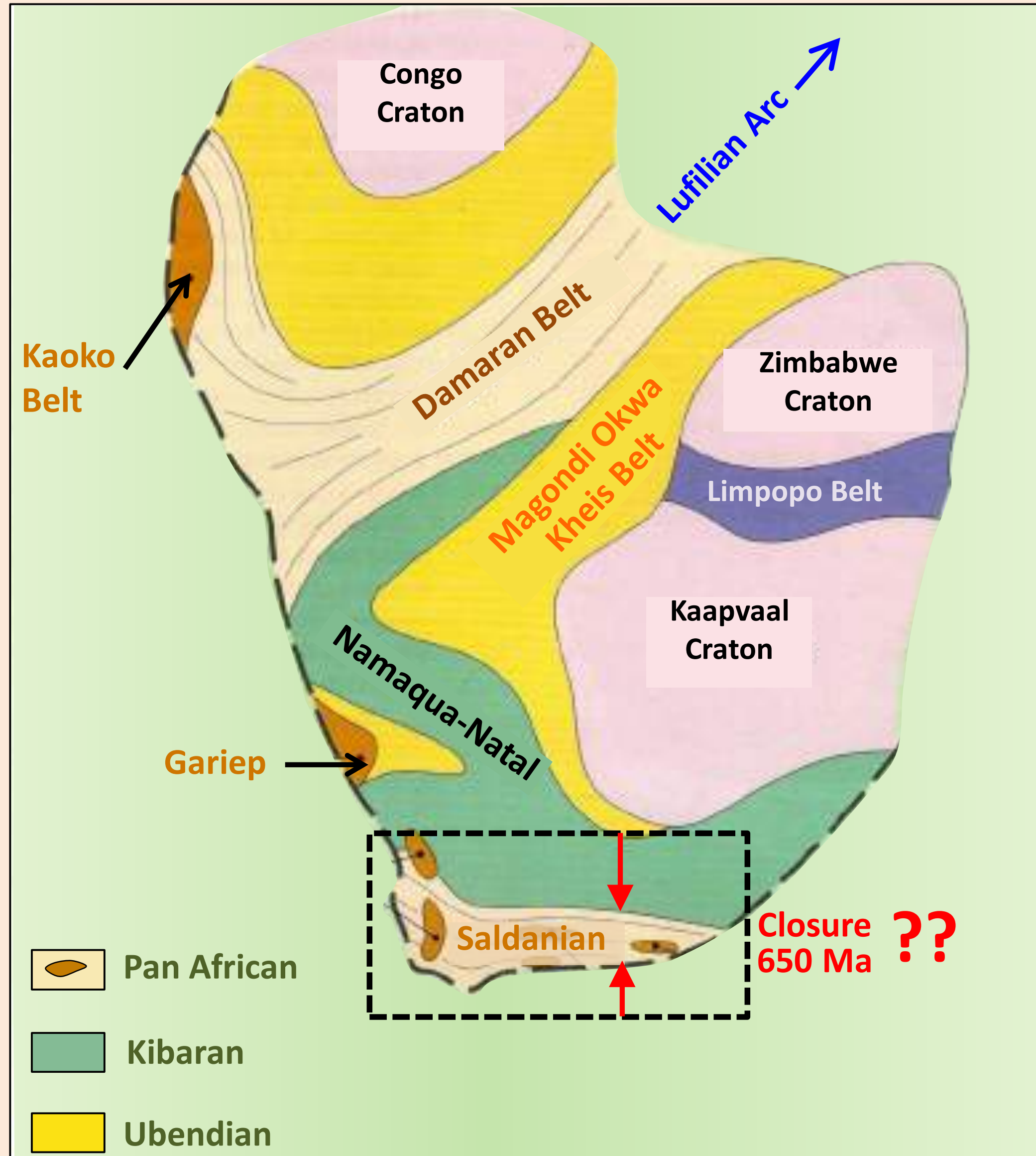
KAAIMANS INLIER

GAMTOOS INLIER

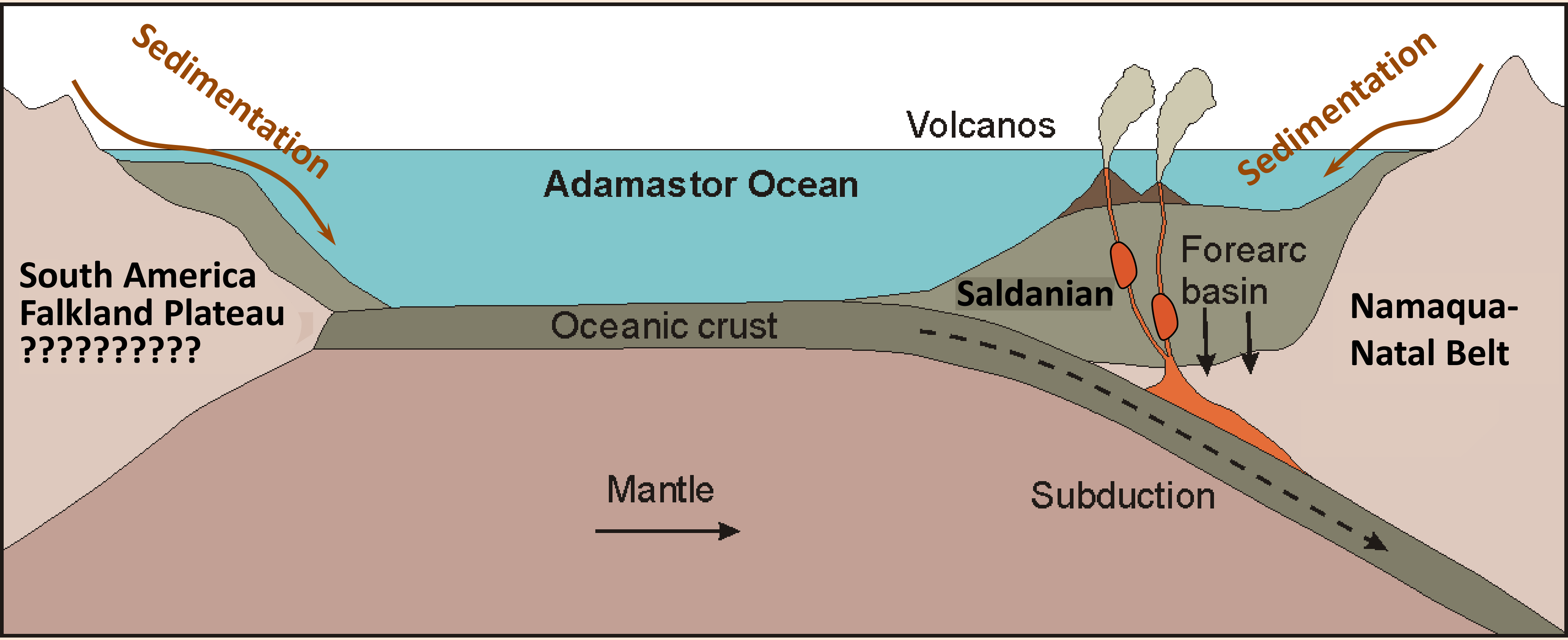
PRE-CAPE BASEMENT - THE PAN AFRICAN SALDANIAN

Break up of Rodinia 780 – 750 Ma

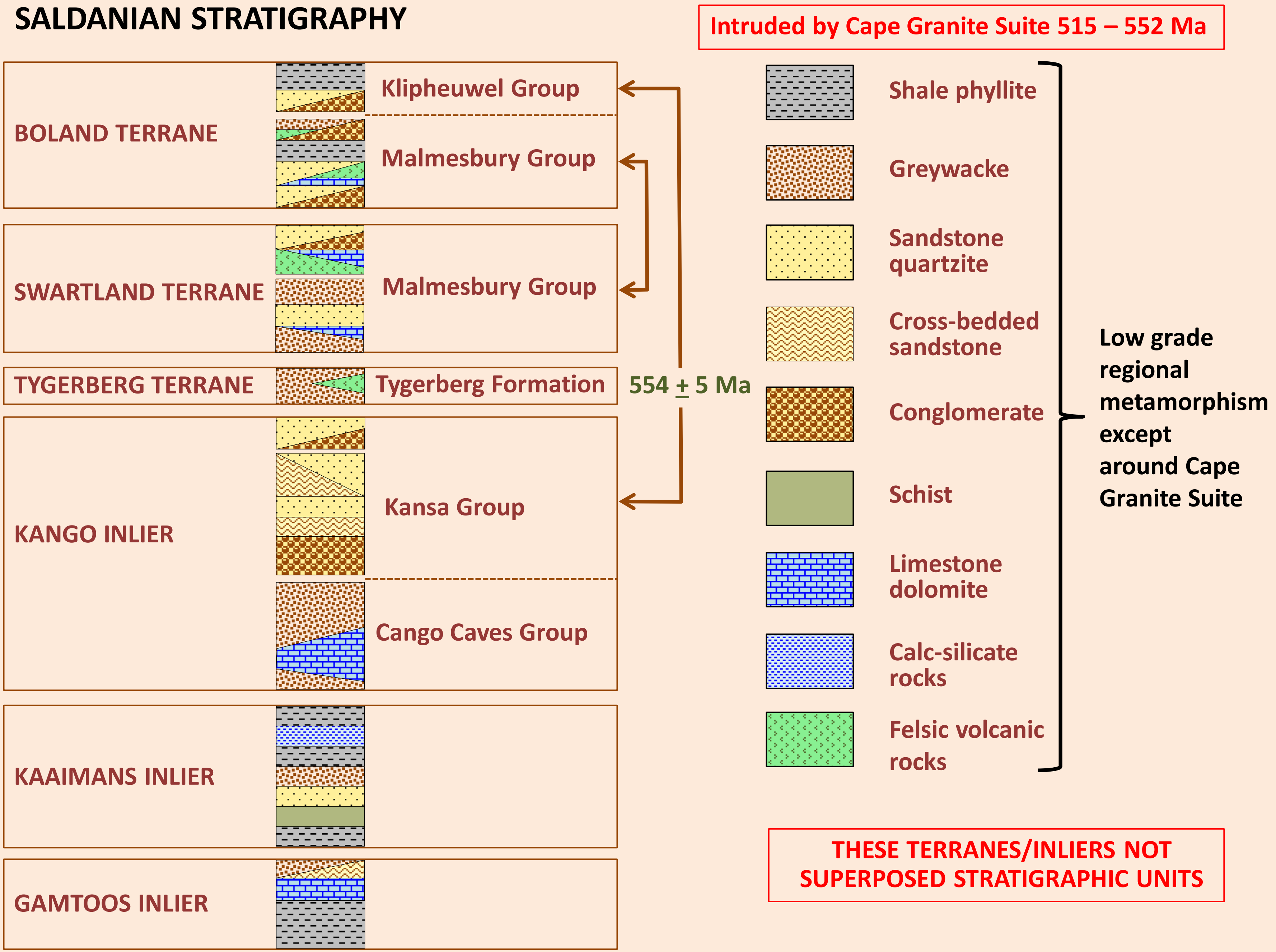




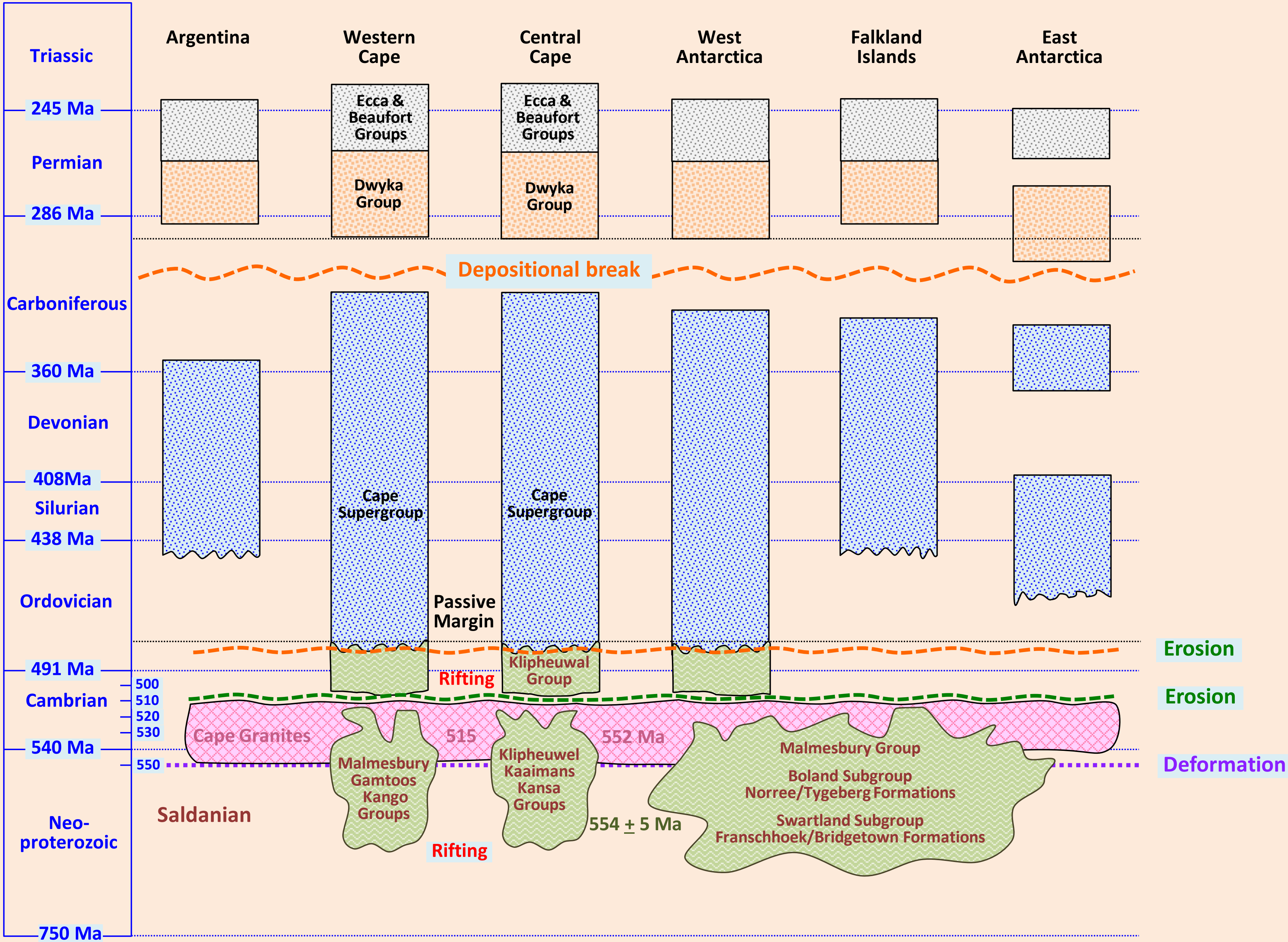
CAPE SUPERGROUP FORMATION OF THE SALDANIAN REMNANTS



SALDANIAN STRATIGRAPHY

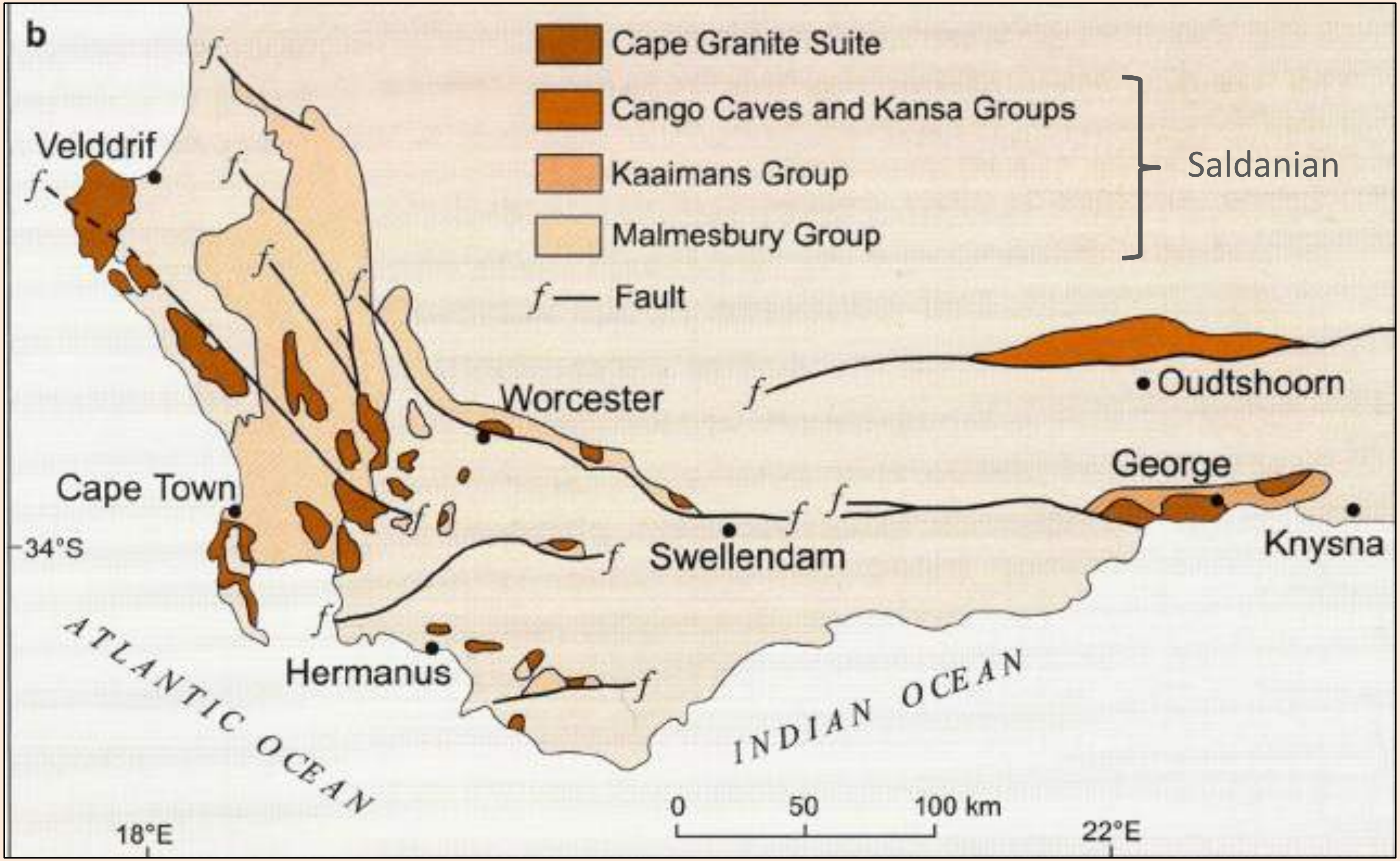


SALDANIA CAPE GRANITES AND CAPE SUPERGROUP

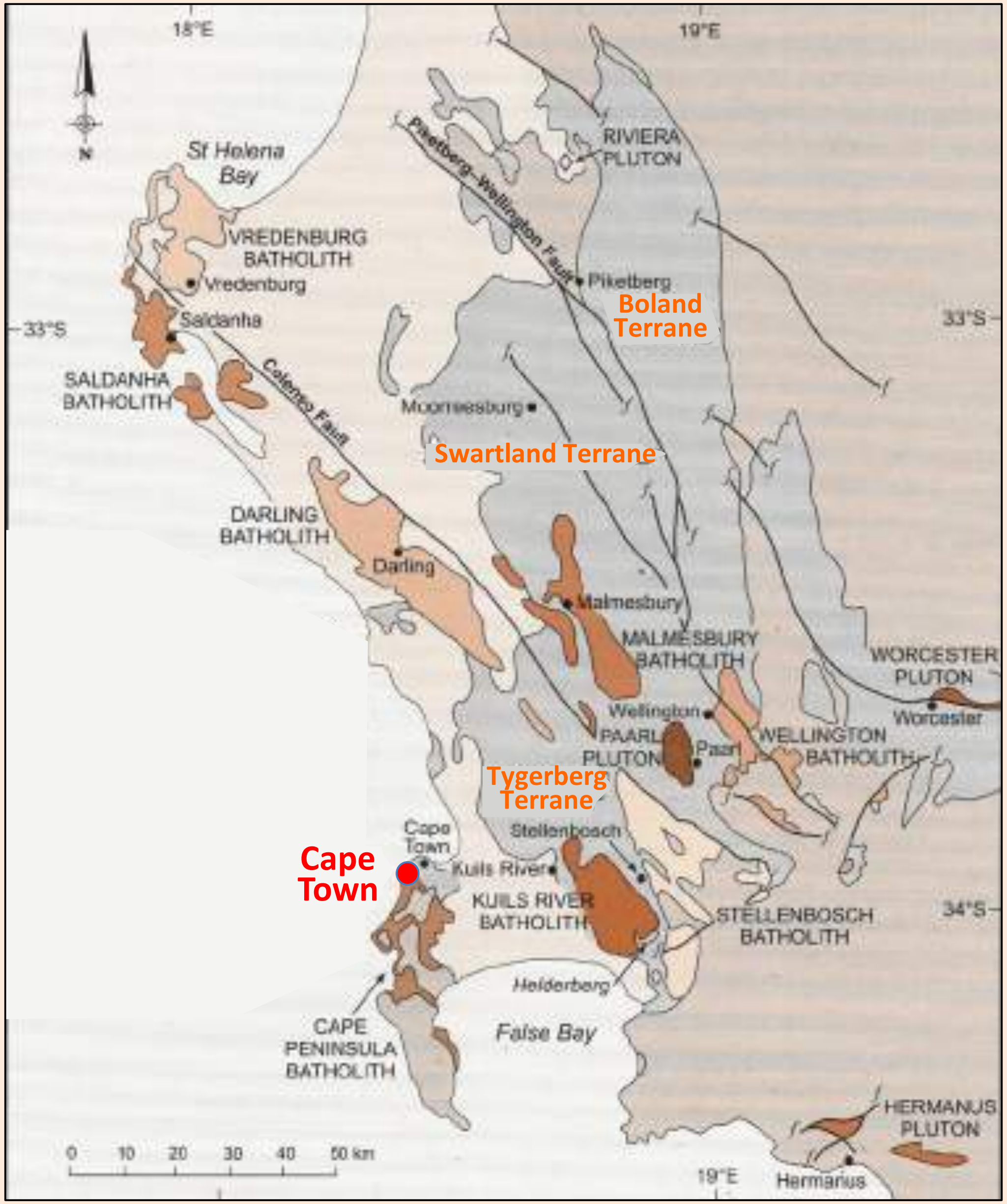


CAPE GRANITE SUITE

DISTRIBUTION OF MAIN GROUPS AND GRANITES



CAPE GRANITE SUITE



Cape Granites

Large number of small plutons

Very little fabric

Porphyritic feldspar megacrysts

Minor rhyodacite

Multiple intrusions four phases

Phase 1 S-Type Granites > 540 Ma

Phase 2 I-Type Granites 540 – 520 Ma

Phase 3 A-Type Granites < 520 Ma

Phase 4 Ignimbrite

CAPE SUPERGROUP

CAPE GRANITE SUITE

Cape Granites

Intrusive contact

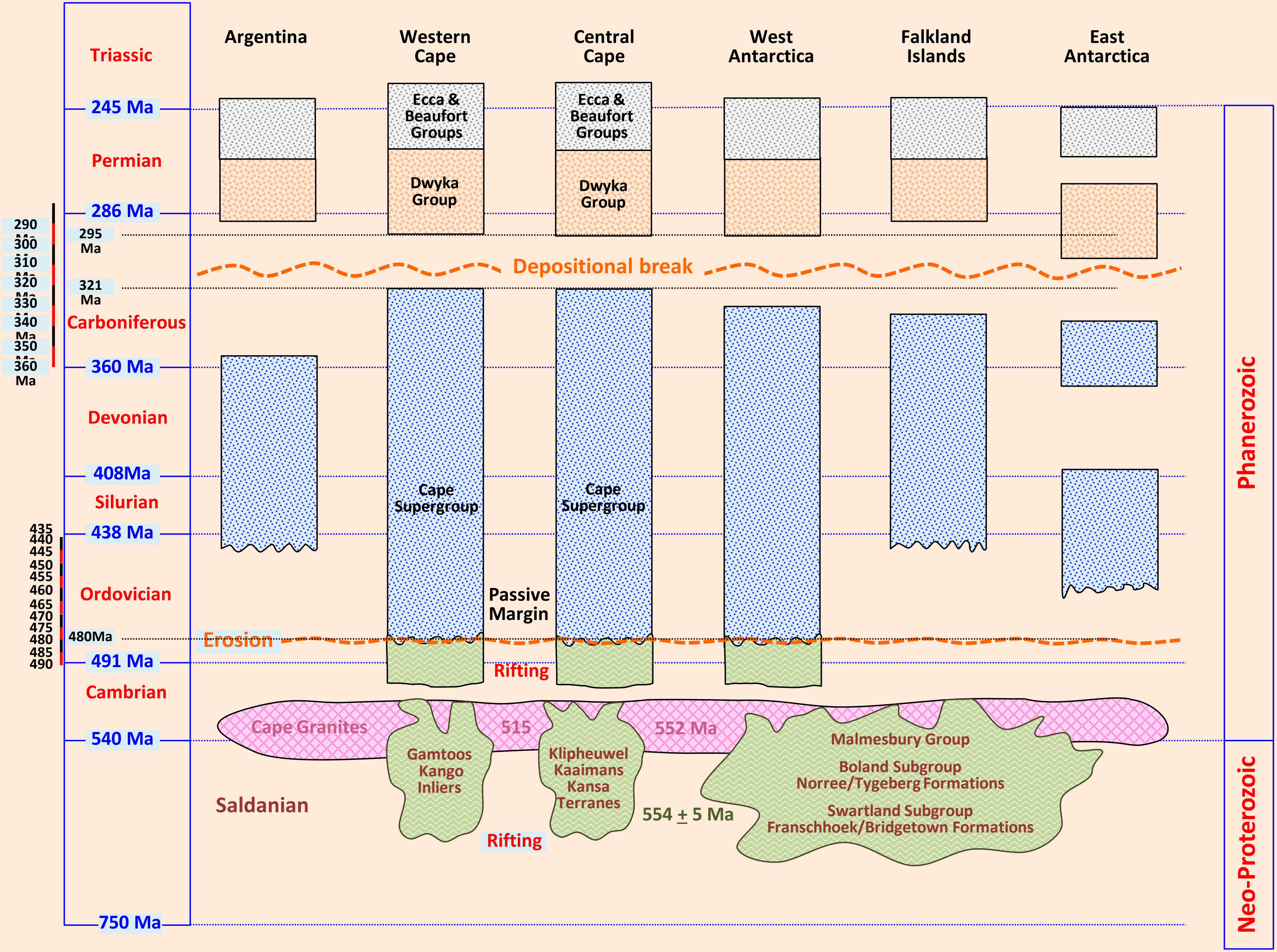
with

Malmesbury

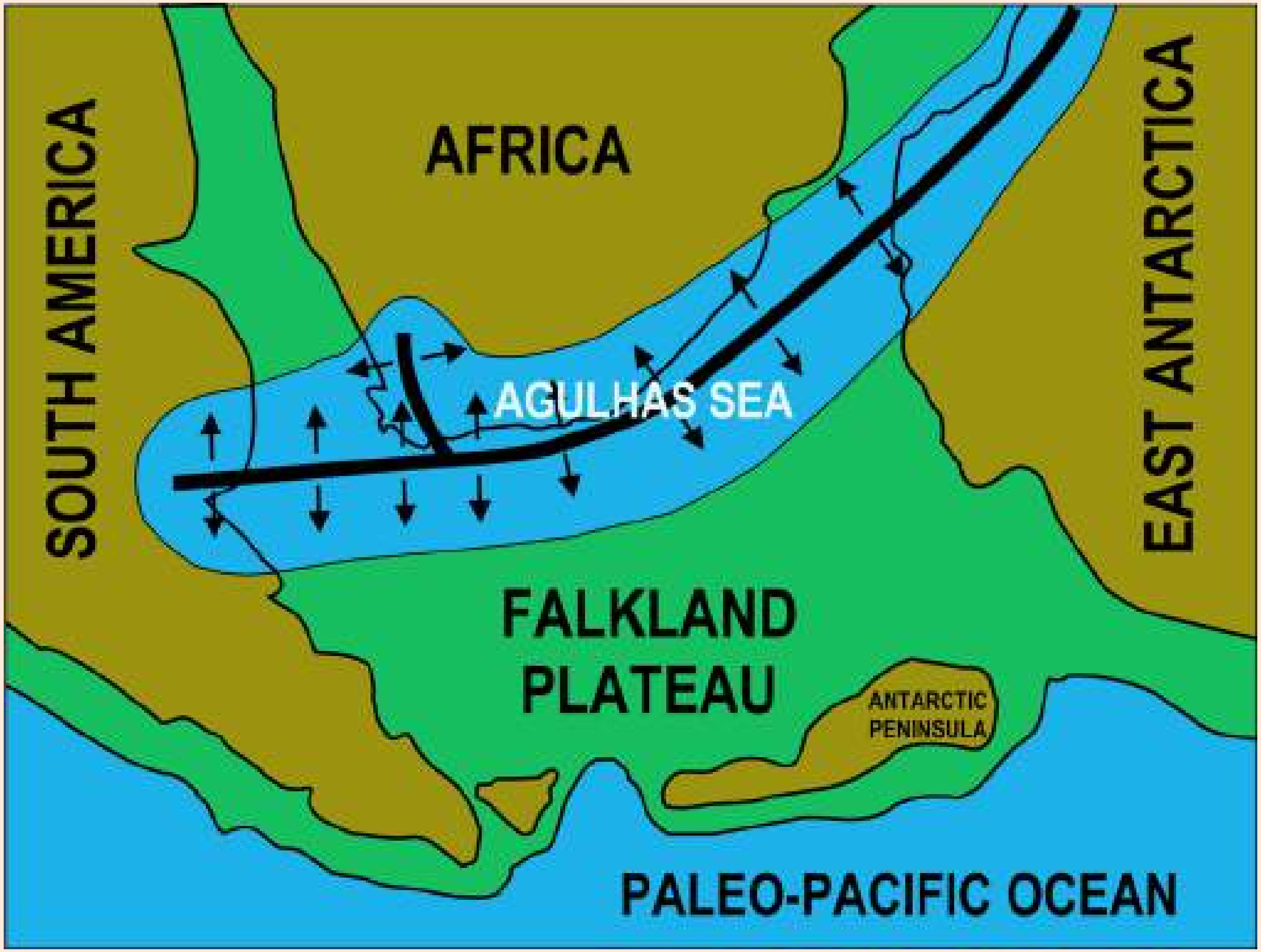
Group


Sandstone
Cape Granite

SALDANIAN CAPE GRANITES & CAPE SUPERGROUP



CAPE SUPERGROUP RIFTING PHASE

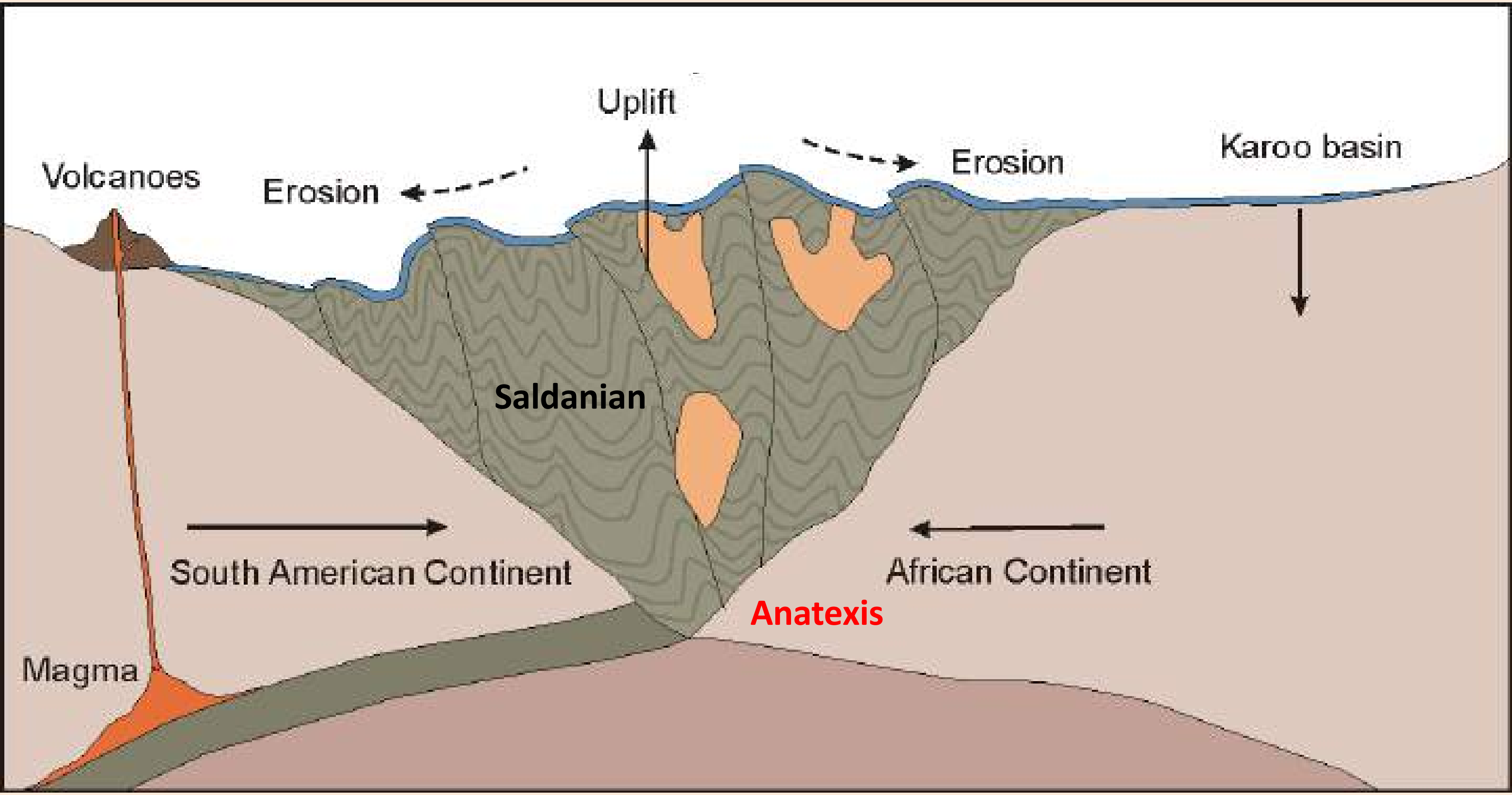


Current Continents

Pre-Cape Continents

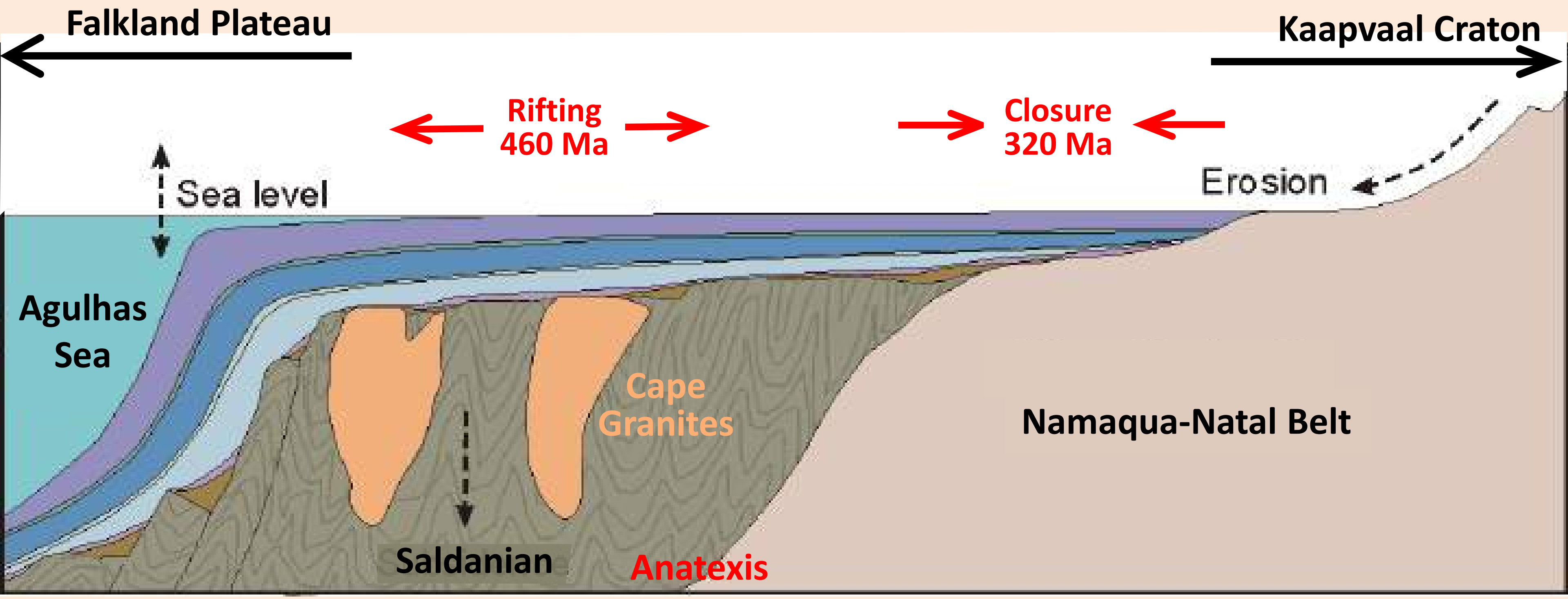
CAPE SUPERGROUP

Subduction south



CAPE SUPERGROUP

Cape Supergroup Passive Margin Sedimentation



Witteberg Group

Coarsening upward repeated transgressive / regressive cycles all shallow marine

Bokkeveld Group

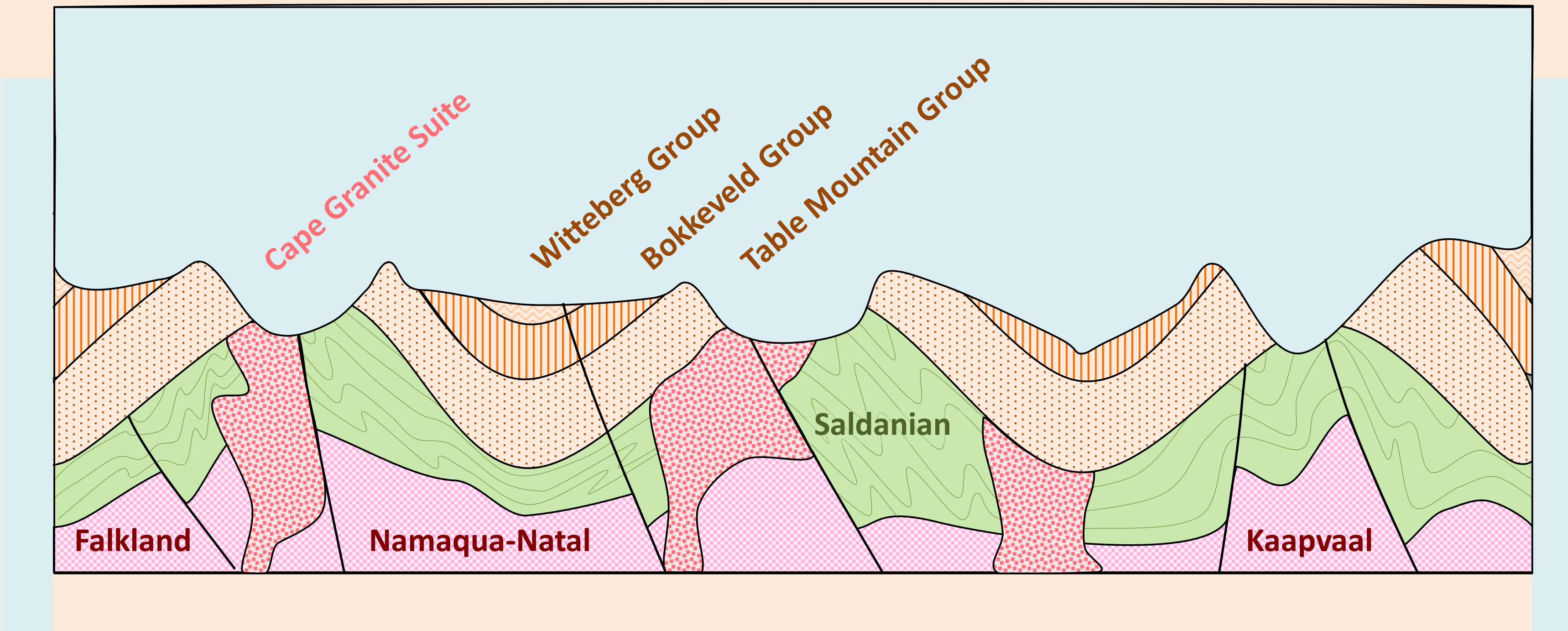
Repeated transgression and regression with coalescing deltas

Table Mountain Group

West – fluvial braid plain with some distal low-energy marine

East – shallow marine

CAPE SUPERGROUP   PRE-CAPE BASEMENT THE PAN AFRICAN SALDANIAN



Saldanian Deposited on Namaqua-Natal Belt and maybe Falkland Plateau

Cape Granite intrusion deformation metamorphism and erosion

Initial rifting with local deposition of Klipheuwal Group

Wider rifting Cape Supergroup Table Mountain / Bokkeveld / Witteberg Groups

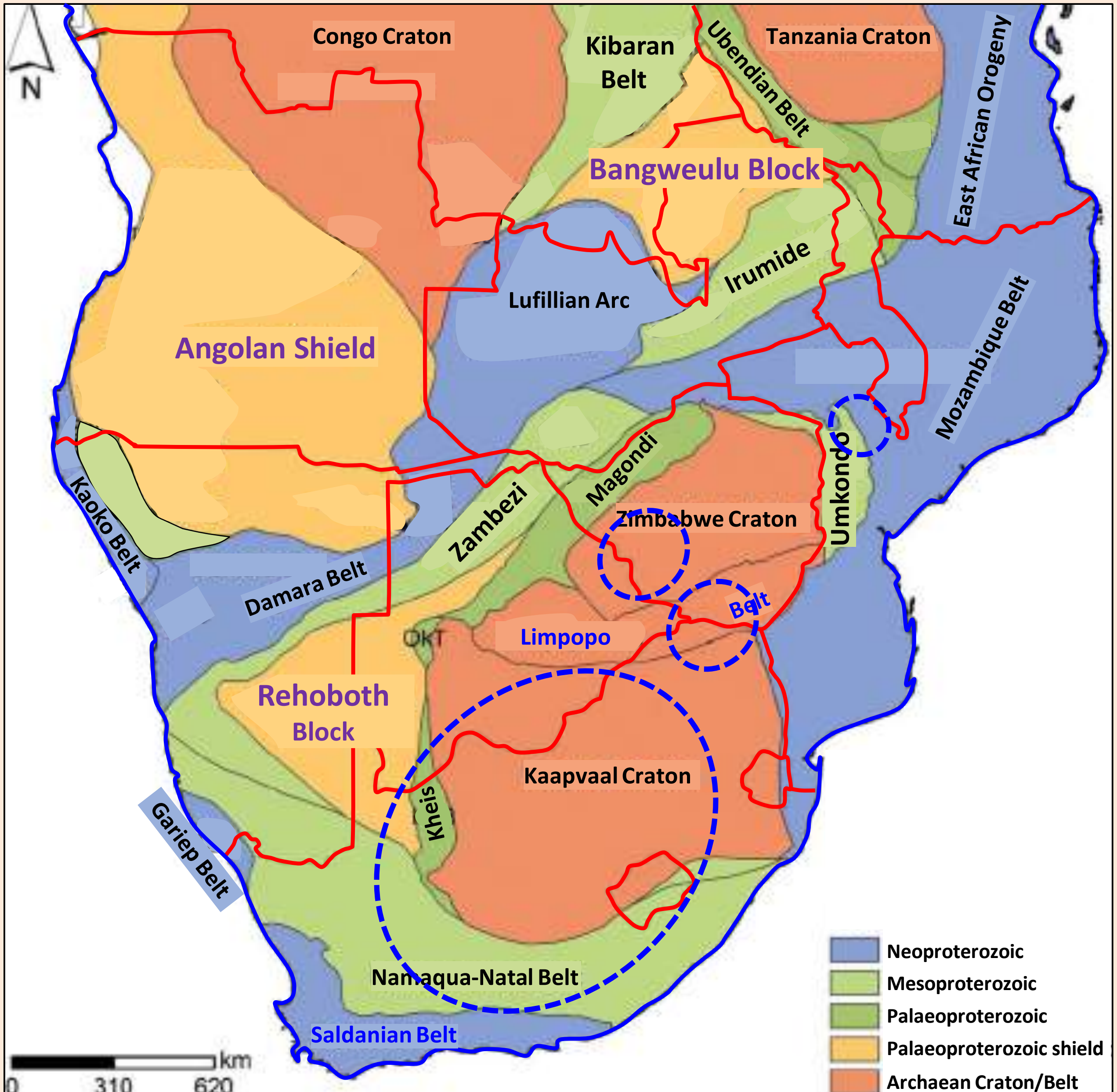
CAPE SUPERGROUP TABLE MOUNTAIN GROUP

CAPE SUPERGROUP **TABLE MOUNTAIN GROUP**

CAPE SUPERGROUP TABLE MOUNTAIN GROUP

KAROO SUPERGROUP

AFRICAN OROGENIC EVENTS



PAN AFRICAN ~ 550 Ma

Cape Fold Belt
Gariep belt
Kaoko Belt
Mozambique Belt
Damara Belt
Lufillian Arc

Gondwana

KIBARAN ~ 1000 Ma

Kibaran Belt
Irumide Belt
Zambezi Belt
Namaqua-Natal Belt
Umkondo

Rodinia

UBENDIAN ~ 2000 Ma

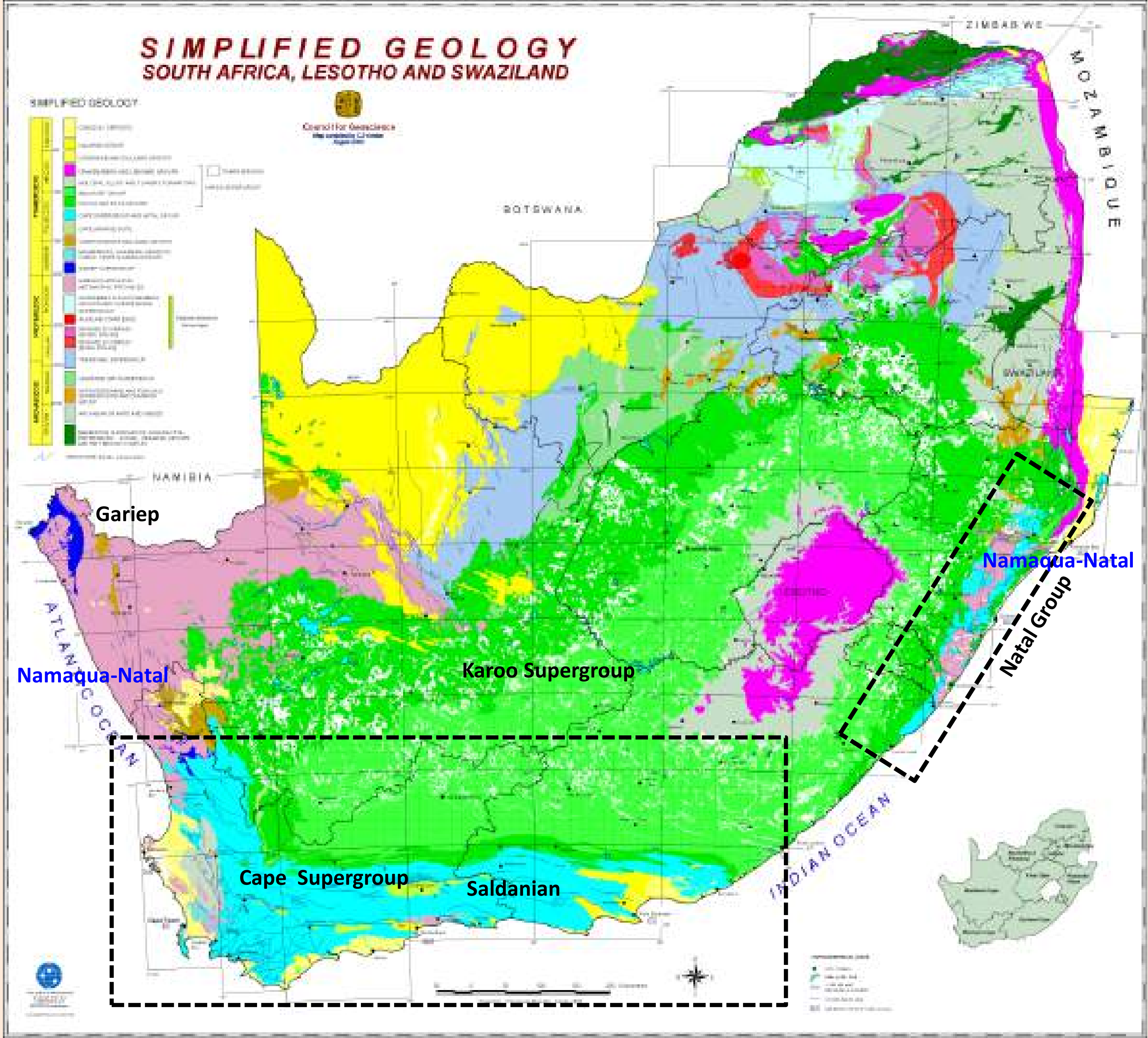
Ubendian Belt
Magondi-Kheis

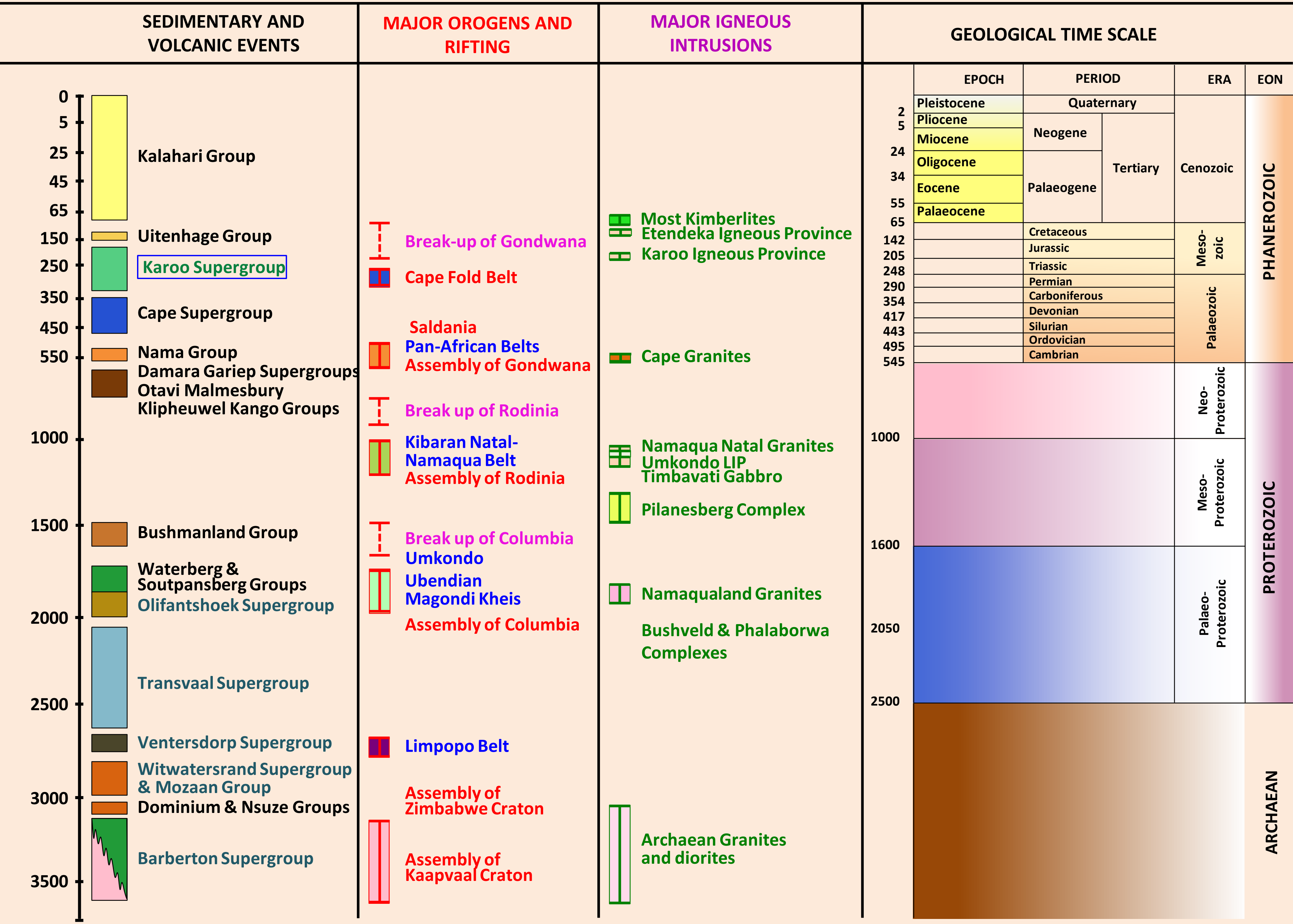
Columbia

ARCHAEAN

BLOCKS/SHIELDS
Archaean/Palaeoproterozoic often under younger cover

Geology South Africa




SEDIMENTARY AND VOLCANIC EVENTS
MAJOR OROGENS AND RIFTING
MAJOR IGNEOUS INTRUSIONS
GEOLOGICAL TIME SCALE
0
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Kalahari Group
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Break-up of Gondwana
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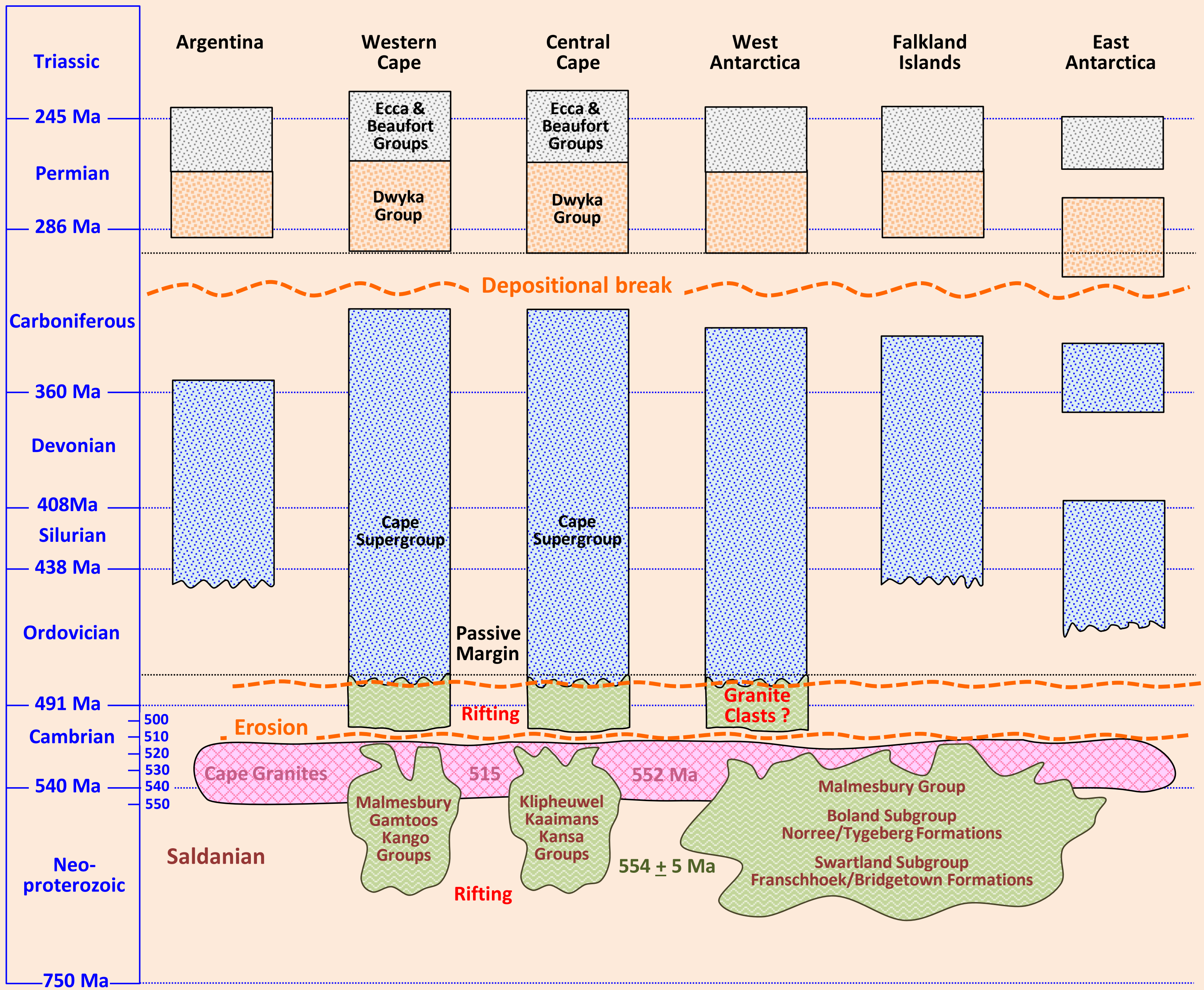
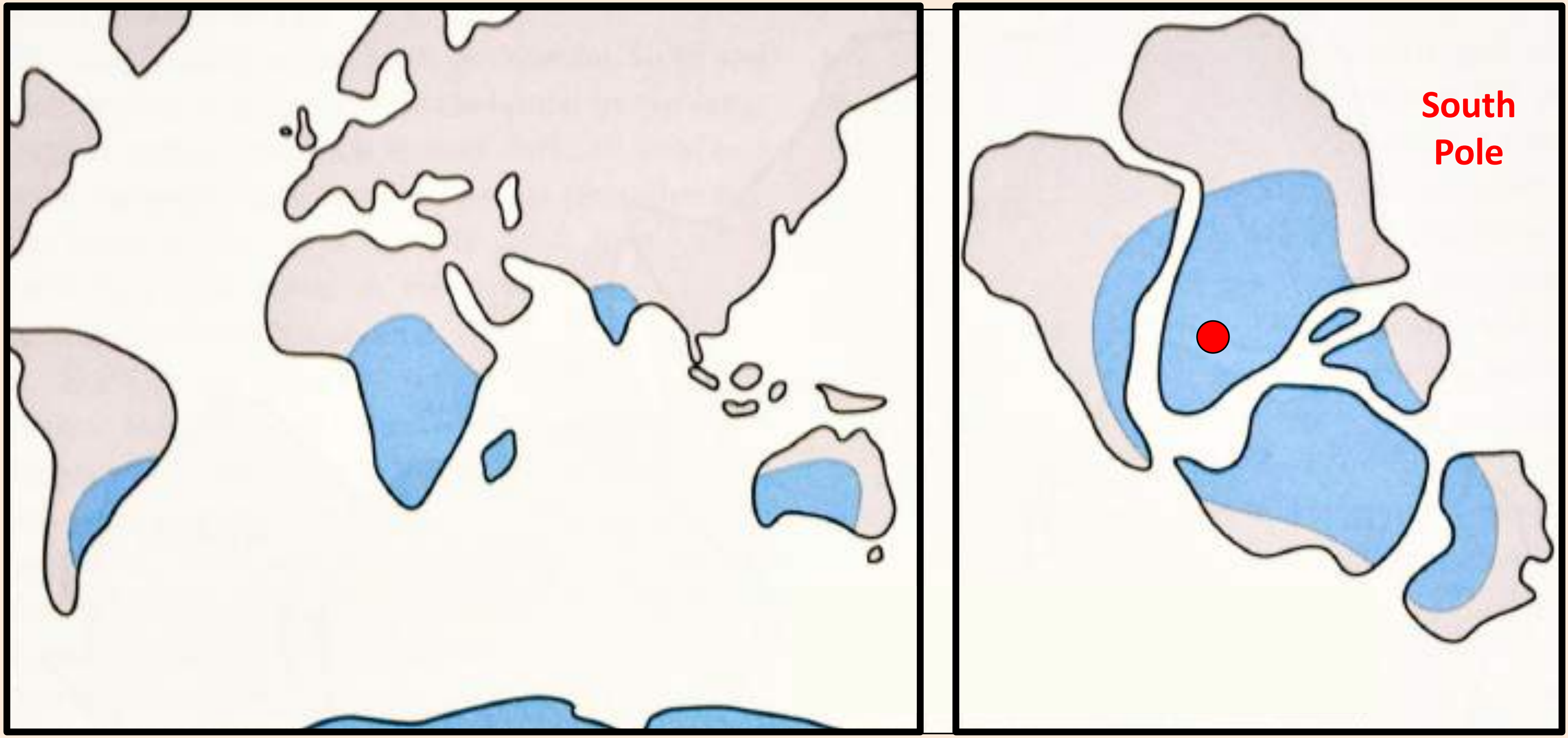
EPOCH
PERIOD
ERA
EON
Pleistocene
Quaternary
2
5
Pliocene
Miocene
Neogene
24
Oligocene
Tertiary
Cenozoic
34
Eocene
Palaeogene
55
Palaeocene
65
Cretaceous
142
Jurassic
Meso-zoic
205
Triassic
248
Permian
290
Carboniferous
354
Devonian
Palaeozoic
417
Silurian
443
Ordovician
495
Cambrian
545
PHANEROZOIC
Neo-Proterozoic
1000
Meso-Proterozoic
1600
2050
Palaeo-Proterozoic
PROTEROZOIC
2500
ARCHAEAN

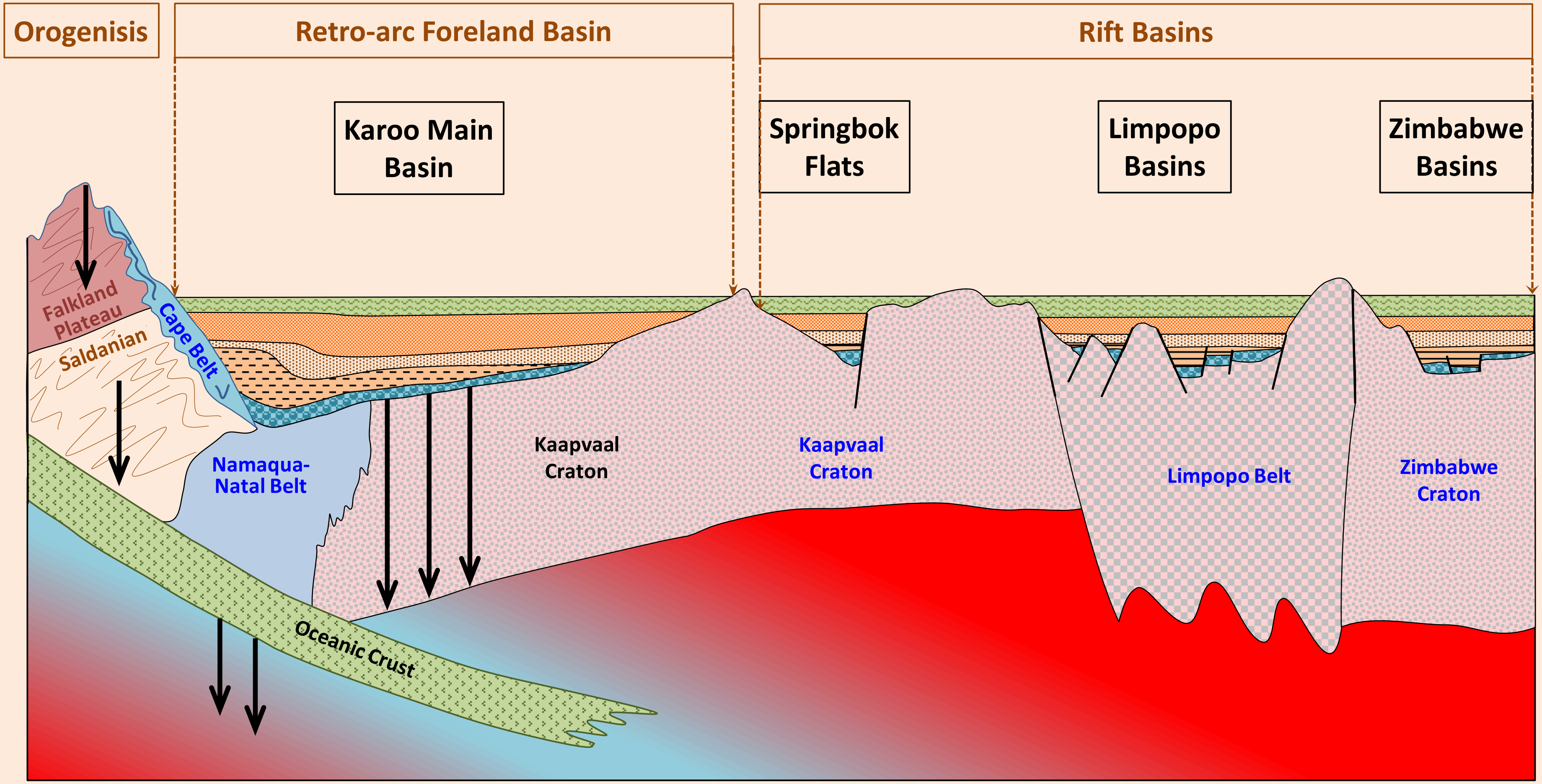
SALDANIA CAPE GRANITES AND SUPERGROUP



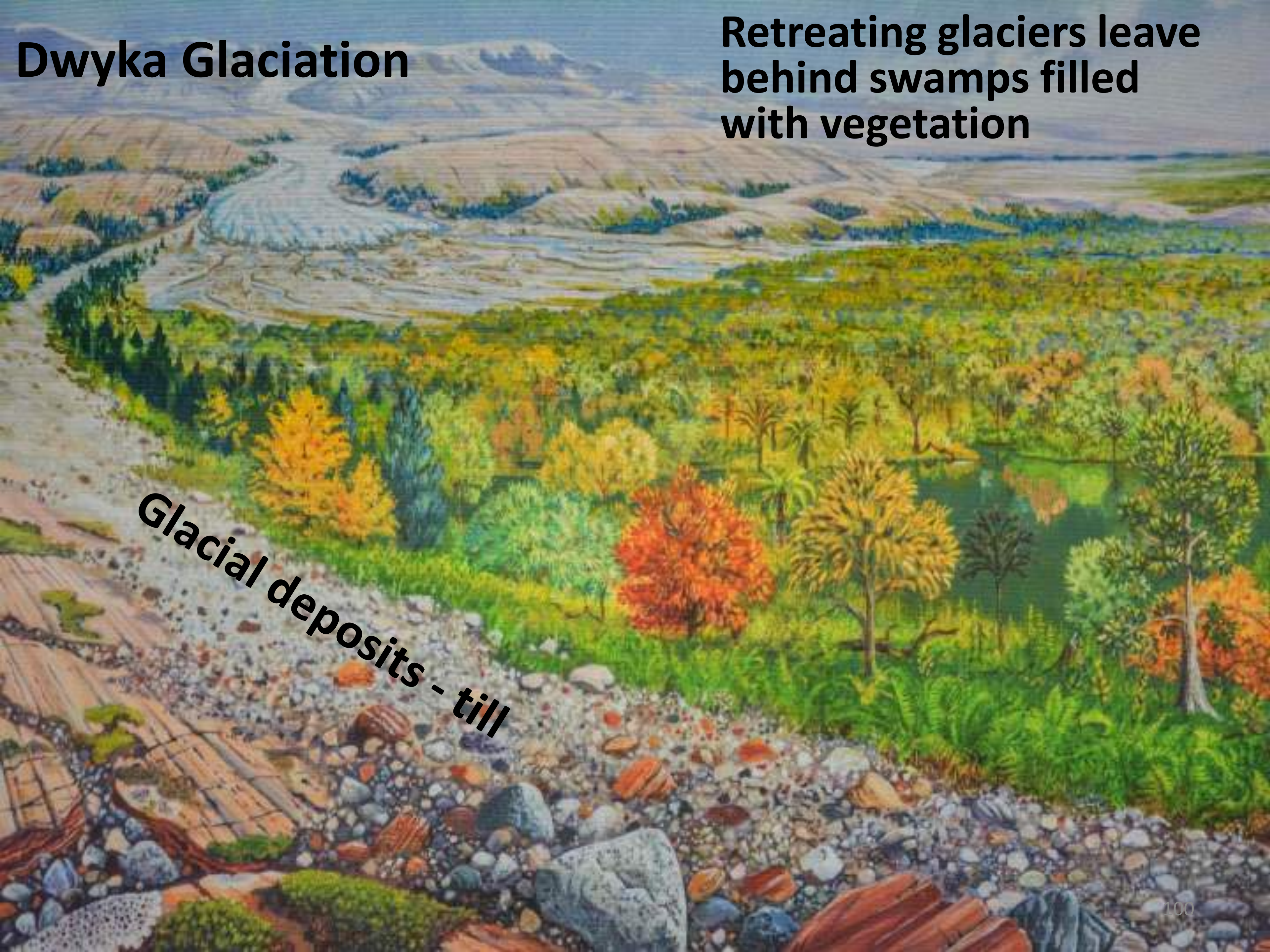
Dwyka glaciation extent

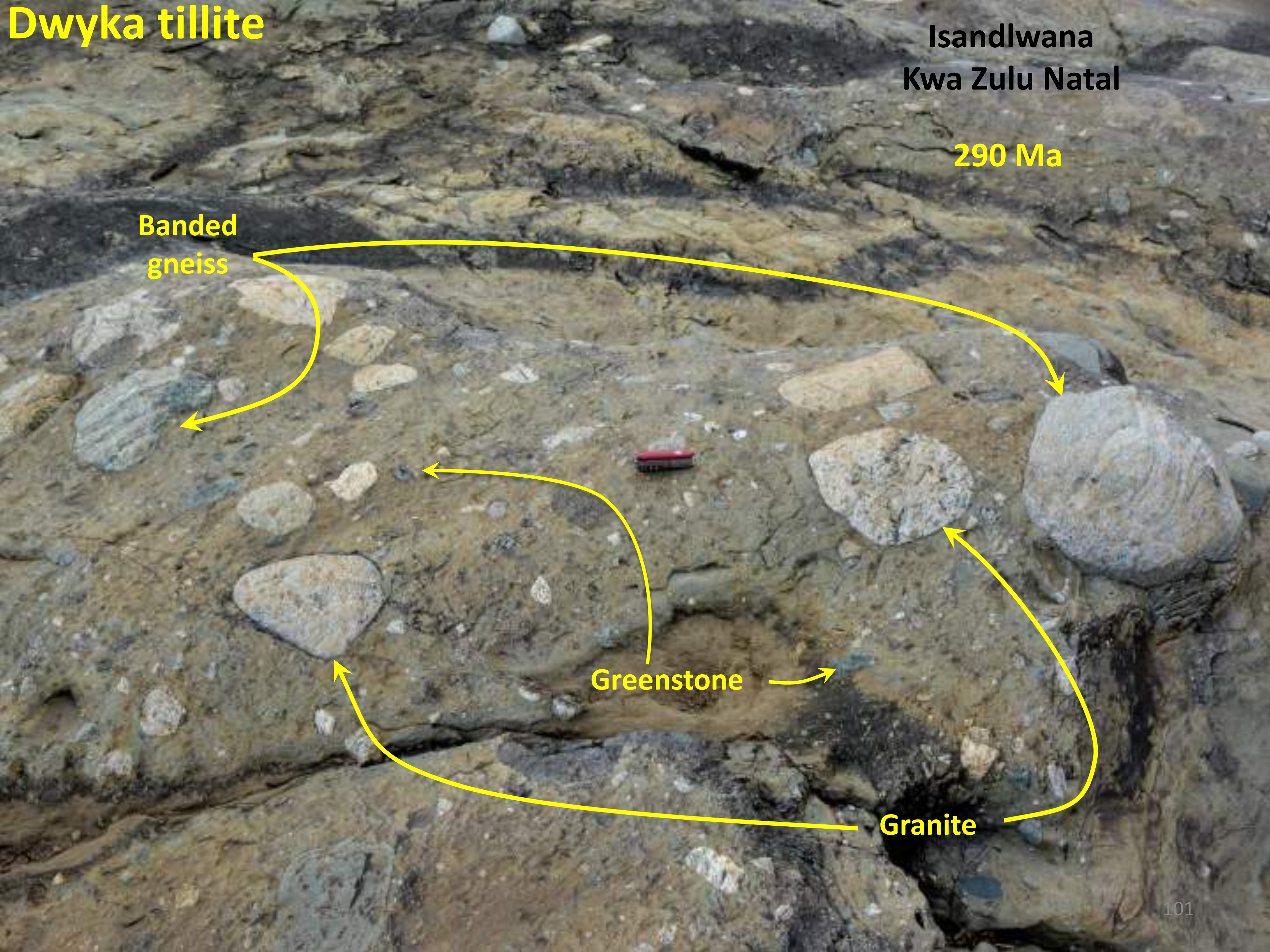


Karoo Supergroup Basin Development



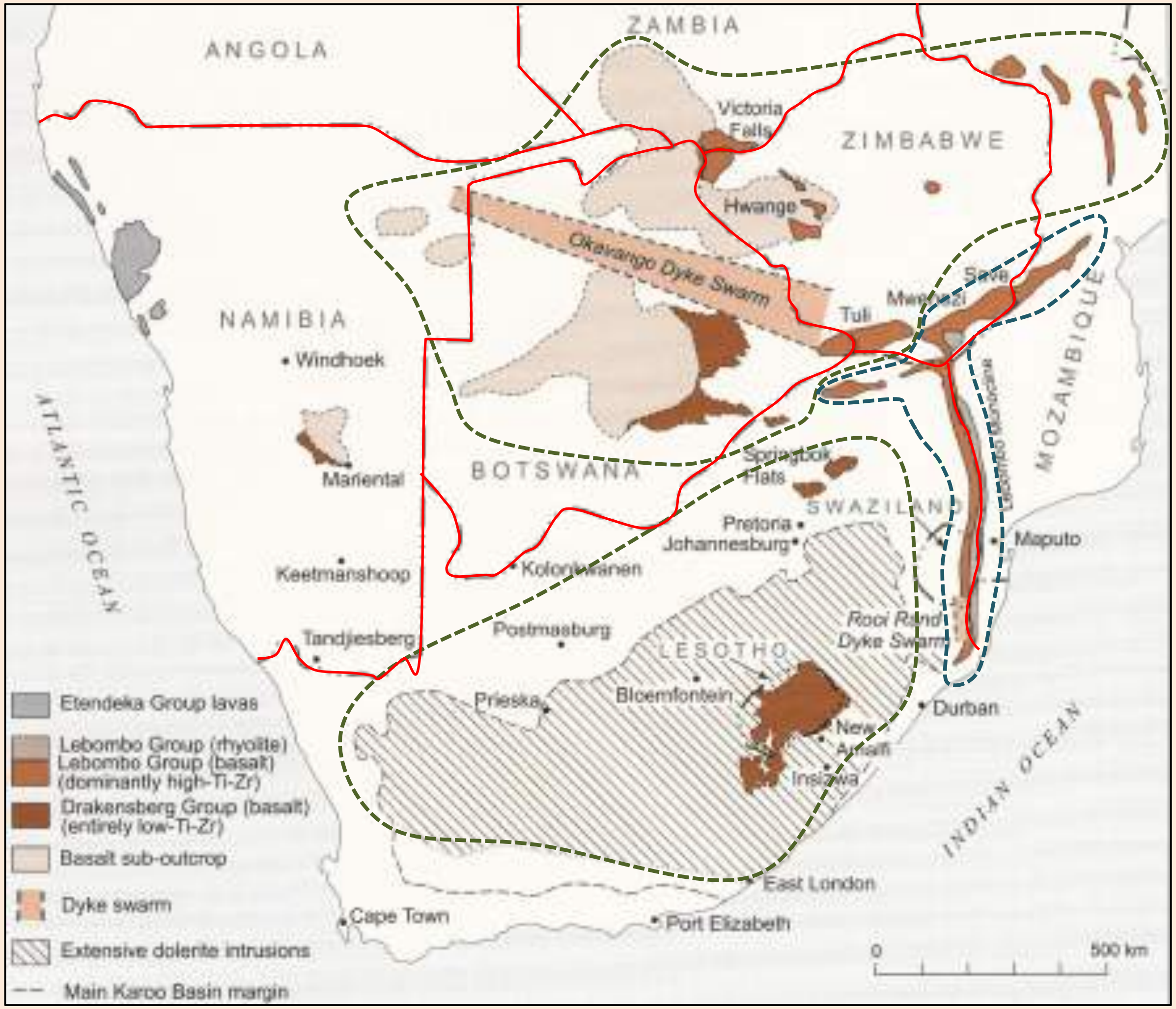
Cold subducting crust descends
Into the mantle and then it bends
The lithosphere and while it sinks,
The mantle cools and then it shrinks.
And thus it forms a foreland basin,
Which is not the type you wash your face in.


Dwyka Glaciation
Retreating glaciers leave behind swamps filled with vegetation
Glacial deposits - till


Dwyka tillite
Isandlwana
Kwa Zulu Natal
290 Ma
Banded gneiss
Greenstone
Granite

KAROO IGNEOUS PROVINCE

KAROO IGNEOUS PROVINCE – A LARGE IGNEOUS PROVINCE LIP



EXTENT

Drakensberg Group

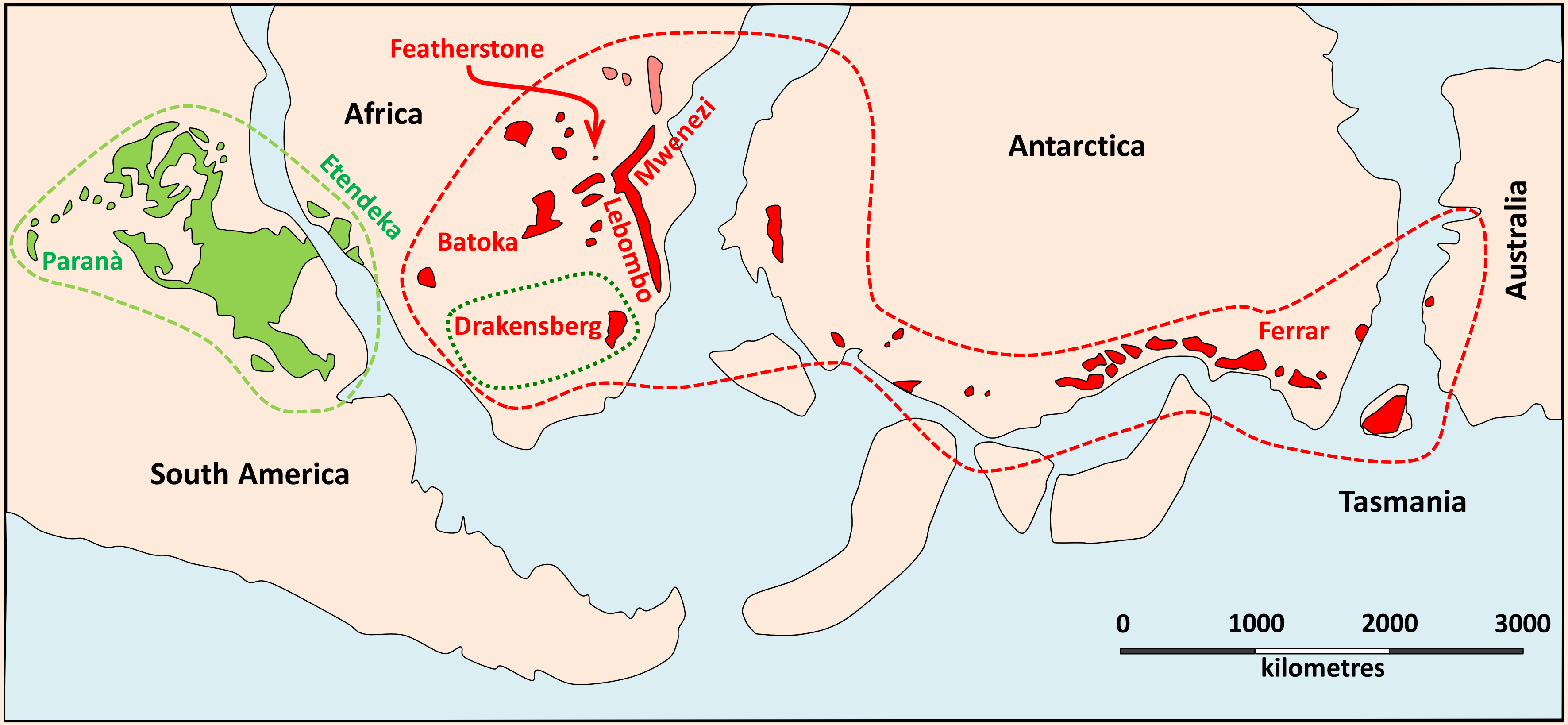
Main outcrop Lesotho

Outliers
Springbok Flats
Botswana
Zimbabwe Zambezi Basin
Zimbabwe Limpopo Basin
Mozambique
Tanzania

Lebombo Group

South Africa/Mozambique border
South Africa Limpopo Province
Zimbabwe Bubye-Sabi Basin

KAROO IGNEOUS PROVINCE



South Africa, Lesotho, and Namibia 183 ± 1 Ma some at 179 Ma

Batoka Basalts 180–179 Ma

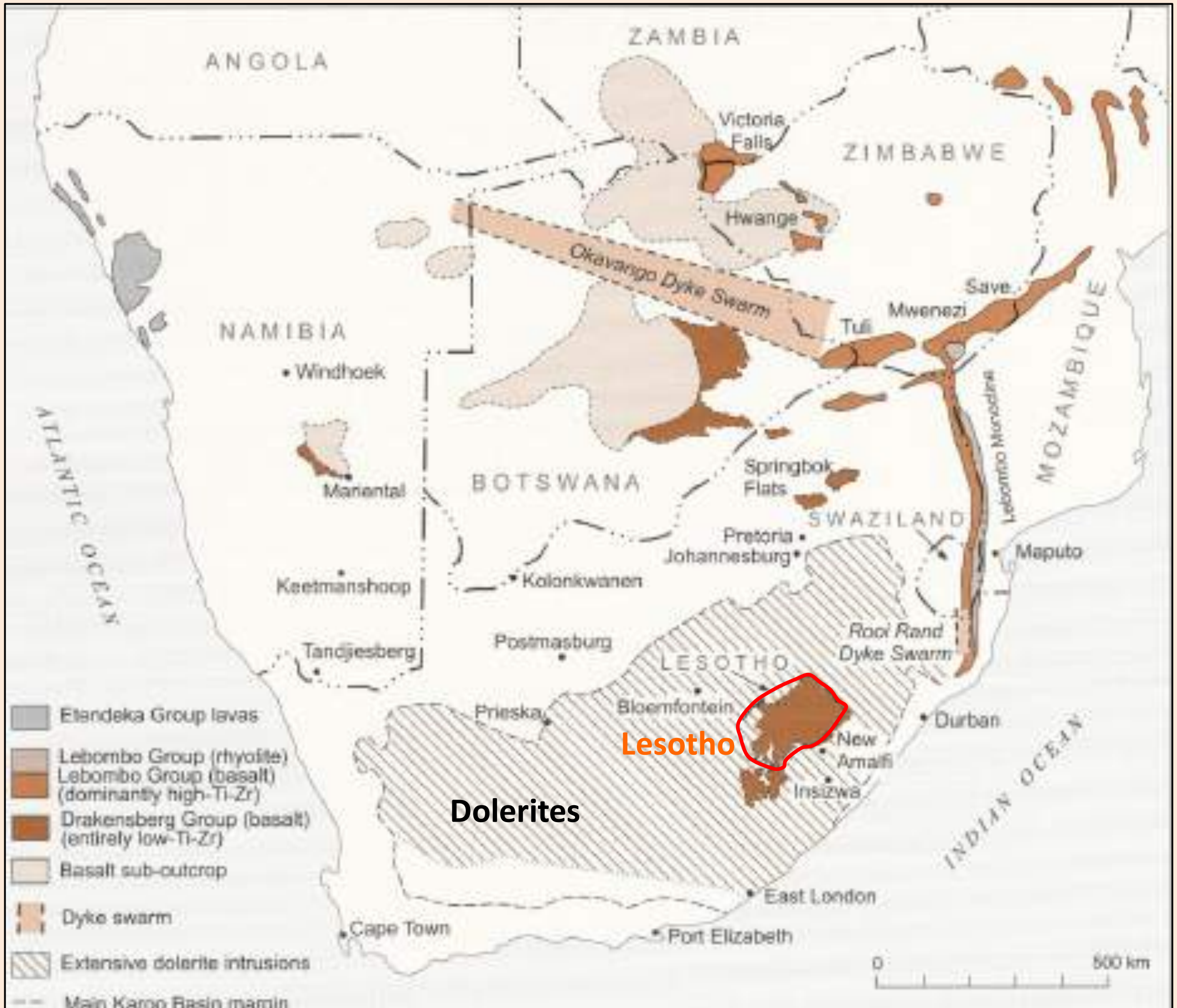
~ 5 Ma emplacement of the Karoo Ferrar Igneous Province ~ 1.5 Ma in South Africa

Karoo Ferrar Large igneous Province

Paraná Etendeka Group ~ 132 Ma

America – Africa Rifting ~ 125 Ma

KAROO IGNEOUS PROVINCE



DRAKENSBERG GROUP

Thickness <1650 m preserved in Lesotho

Mostly fissure eruptions lava flowing up to 60 km from source

Stacked basaltic lava flows 10 – 20 m thick

Basal flows thinner and of more variable composition

Widespread dykes and sills up to 400 m thick

Up to 5000 m in some of the rifted basins

Chemistry different north to south – two mantle sources

Palaeomagnetic polarity reversal in lower flows

KAROO IGNEOUS PROVINCE DRAKENSBERG

Age 183 $\underline{+}$ 1 Ma – very short period of activity of 1-5 Ma over African extent like most Continental Flood Basalts

Basal flows conformable on Stormberg sediments

Individual flows 60 km from source

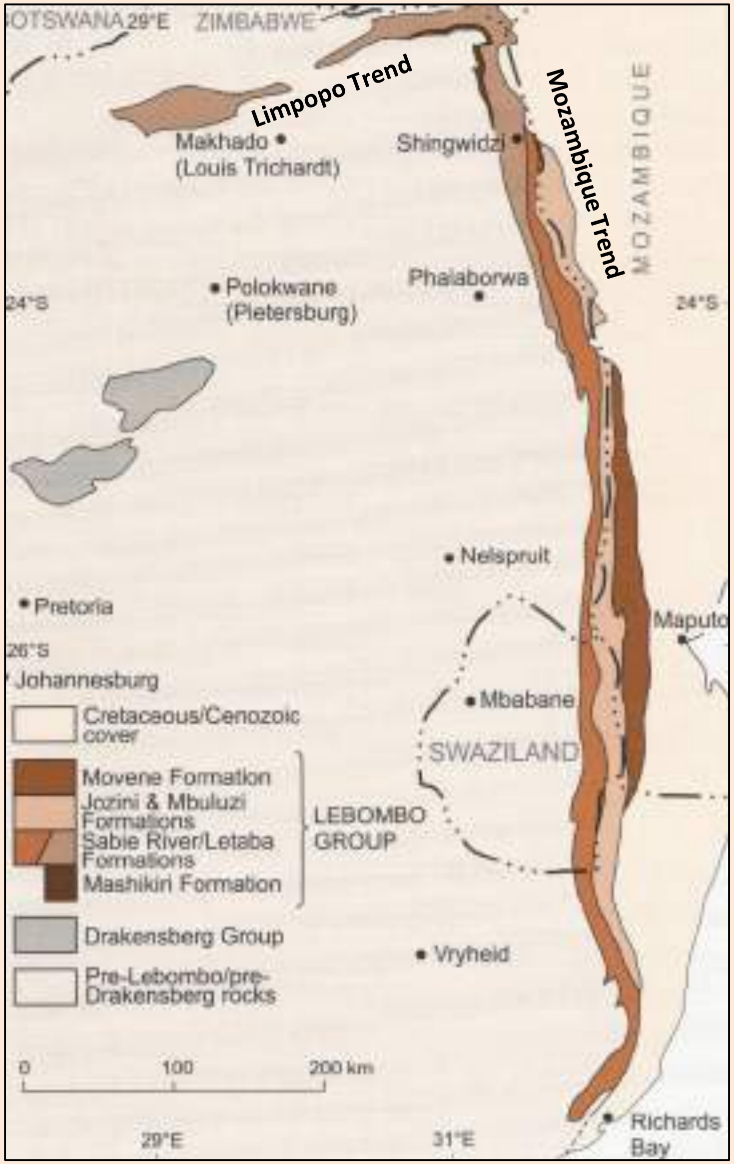
Locally sub aqueous with pillows and interbedded sandstones

Current remnants (140,000 km^2) of a much larger area estimated at 2,000,000 km^2

Even greater area intruded by dykes probably overlain by lava

KAROO IGNEOUS PROVINCE BATOKA BASALTS

KAROO IGNEOUS PROVINCE



LEBOMBO GROUP

Linear belt parallel Mozambique trend

1000 km including 200 km westerly (Limpopo trend – two segments)

~ 4500 m thickness difficult to estimate due to faulting

Six Formations of different lithologies

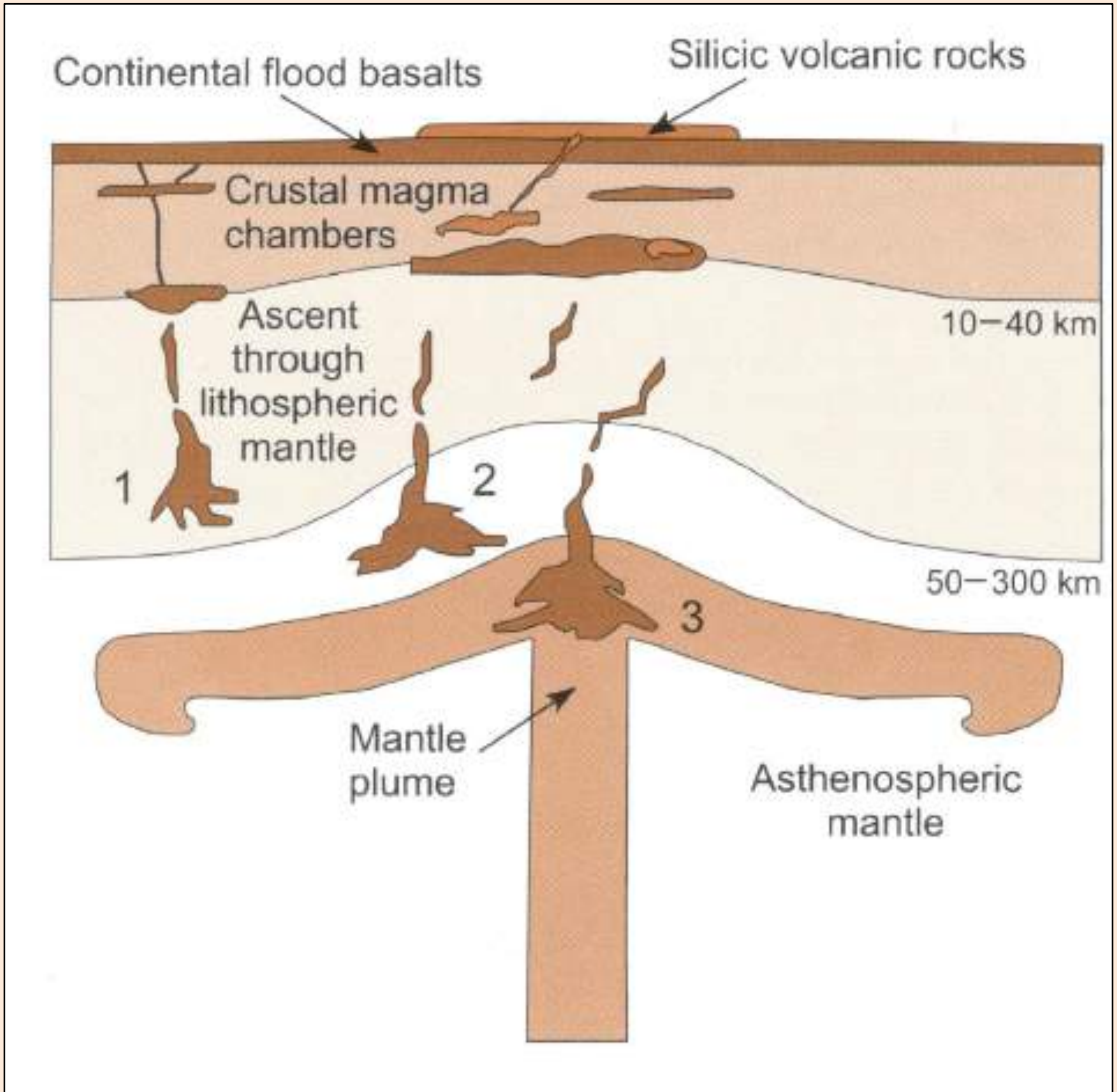
Basalt
Rhyodacite
Picrite – extrusive olivine pyroxene biotite <10% plagioclase
Nephilinite – extrusive/hypabyssal nepheline & clinopyroxene

LEBOMBO GROUP ORIGIN

Silicic volcanics from partial melting of older gneissic or basaltic rocks near the crust mantle boundary - underplating

Large volume crustal melting requires large heat source and mafic intrusion likely along a rift

Reactivation of fractures along Limpopo and Mozambique Belts



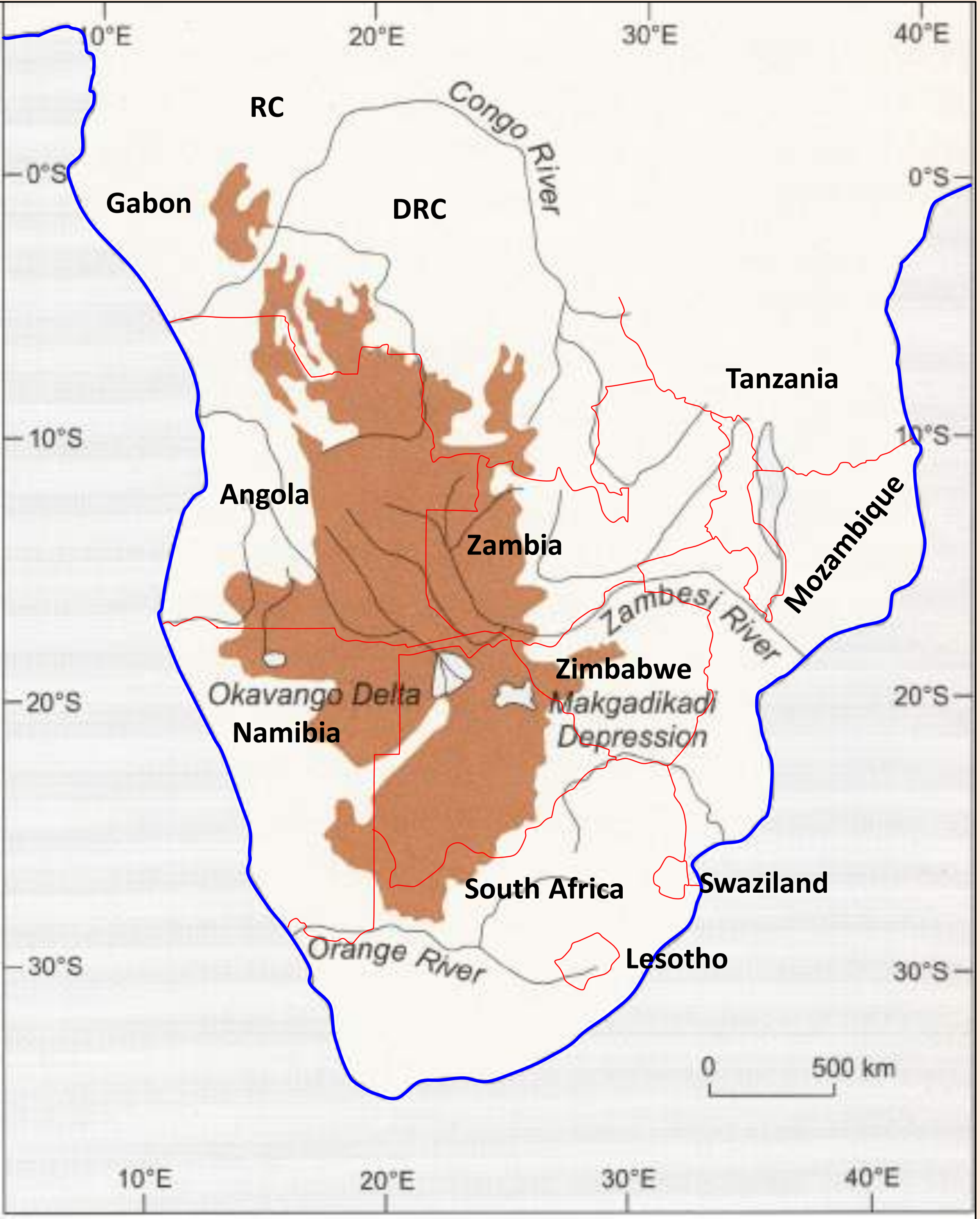
LEBOMBO GROUP EMPLACEMENT MODEL

Mantle plume and partial melting to produce basalt

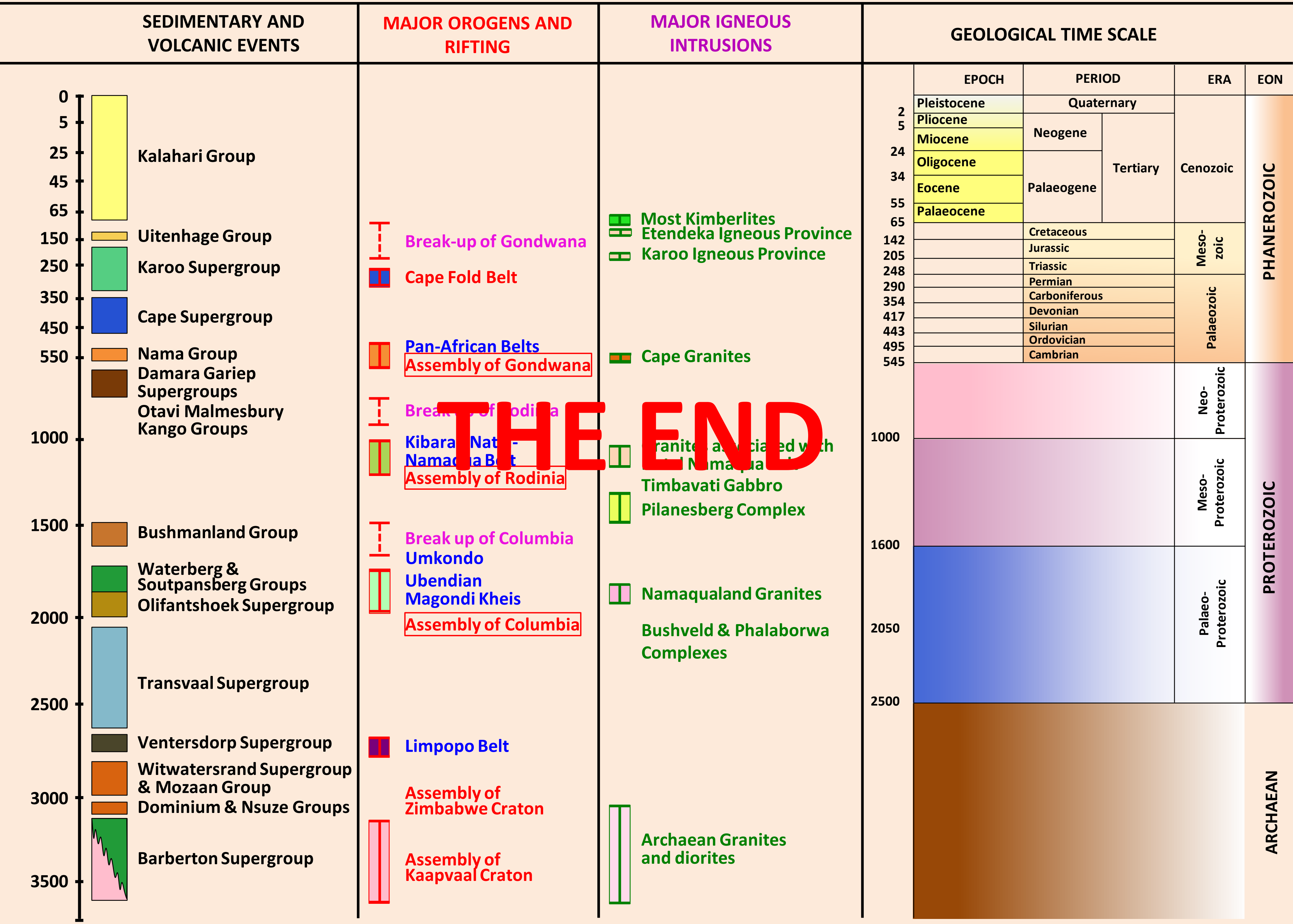
Two magma types in Drakensberg Group suggest different mantle source compositions

Varying degrees of crustal contamination

Remelting of sialic crust to produce rhyolite/dacite/nephilinite



KALAHARI GROUP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THE END