# The Great Dyke of Great Treasures and Great Mysteries

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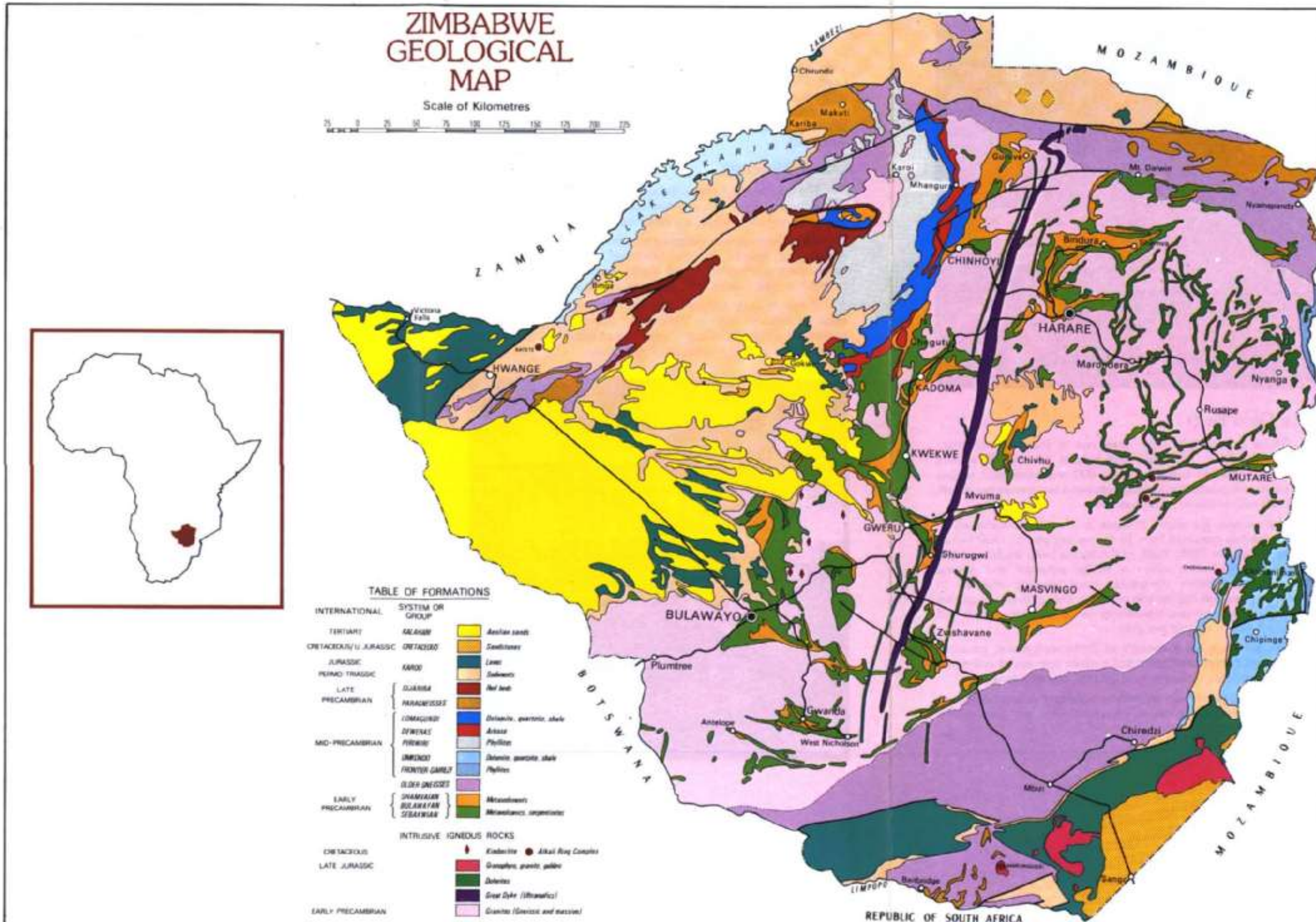
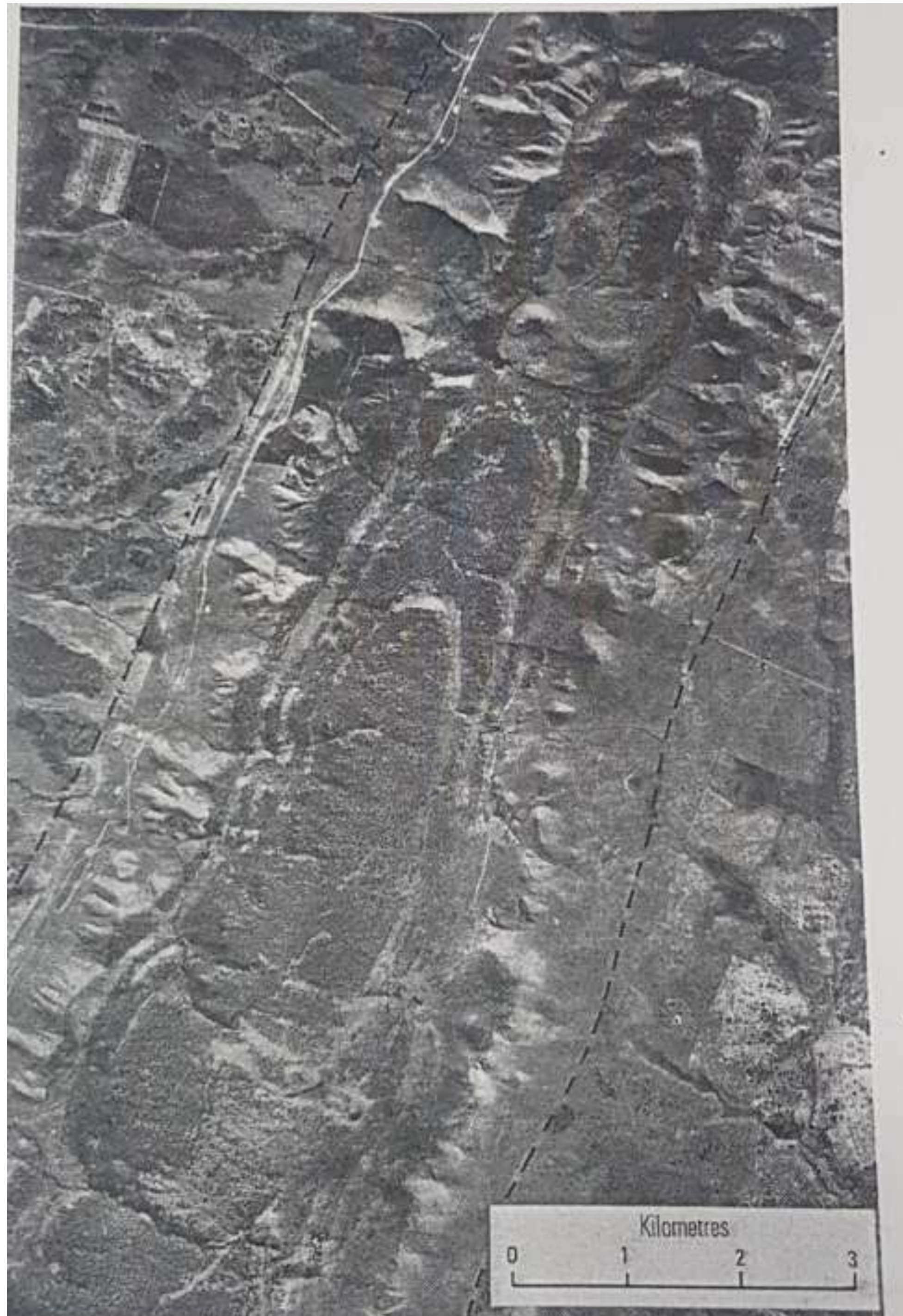
# At over 530km long and up to 12 km wide, the Dyke stands out conspicuously on the geological map of Zimbabwe

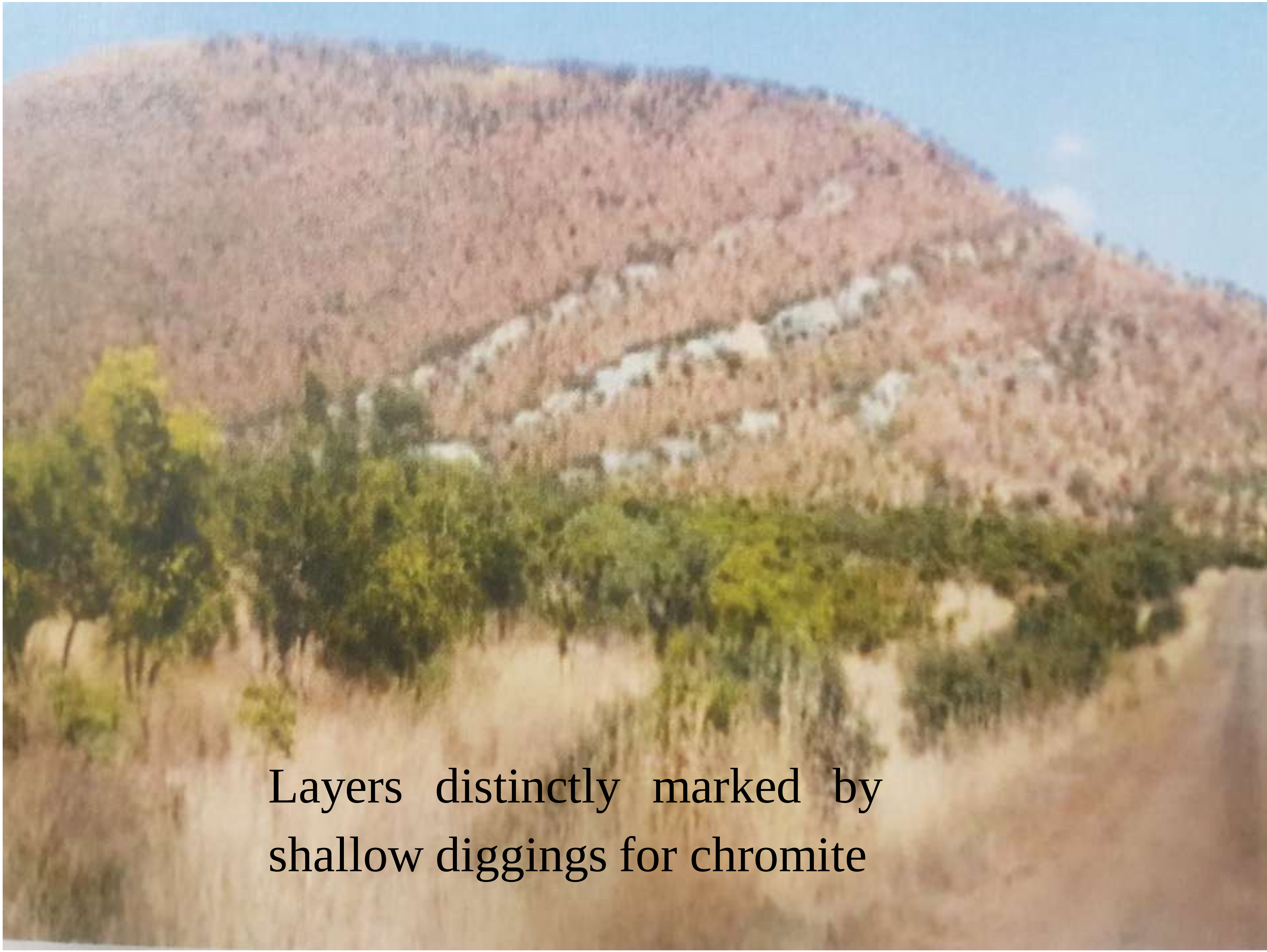



•Clearly visible from outer space
•Longest igneous complex in the world;
•6th largest igneous complex

Layers clearly discernible from air.

The contacts are sharply defined by two wide vleis flanking each margin, which together with the linear nature of the Dyke make it a most noticeable feature when viewed from above




Layers distinctly marked by shallow diggings for chromite

# Great in mineral wealth

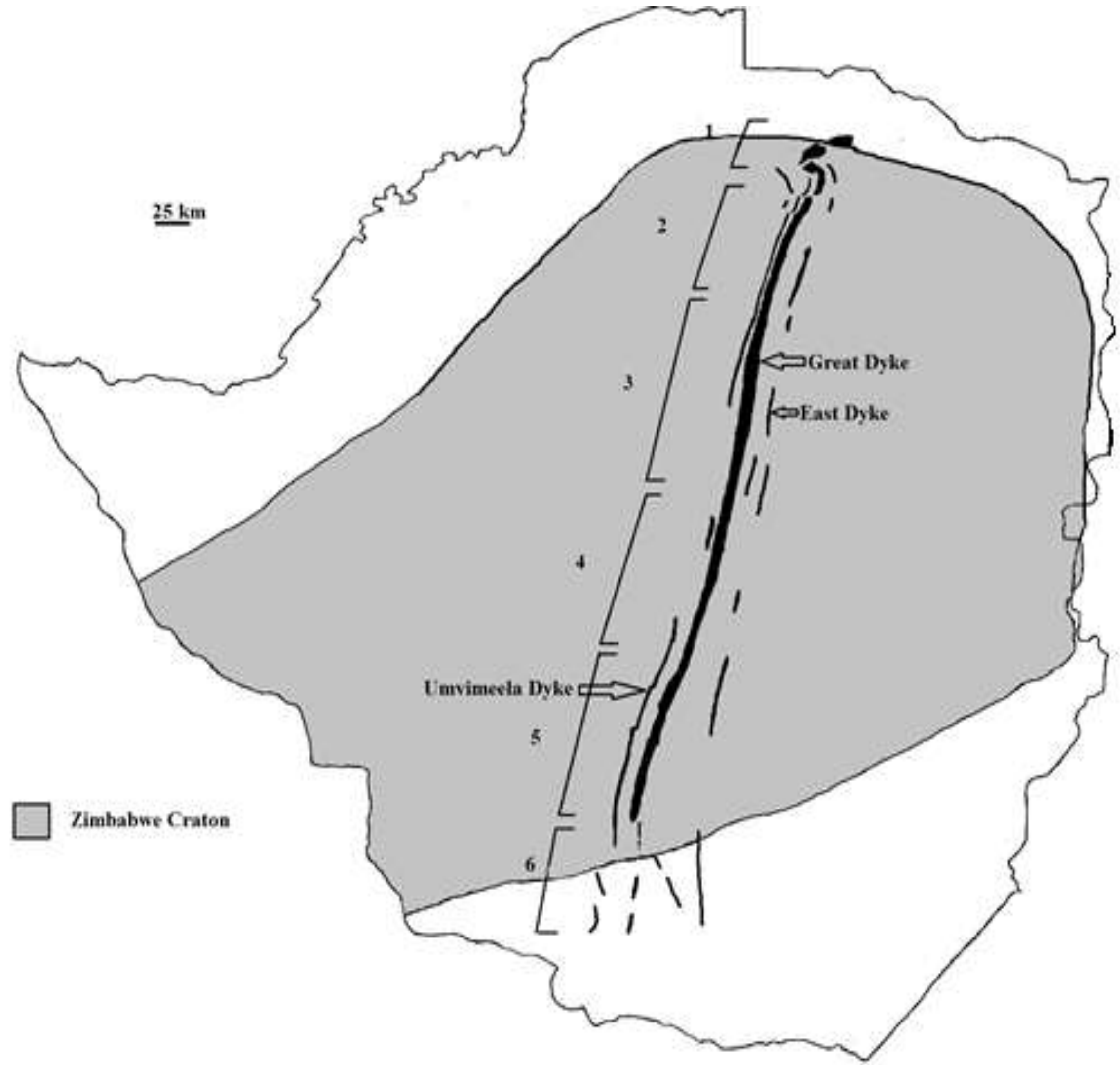
| | | |
|---|---|---|
| Platinum Group metals | >2.8 billion tonnes @4g/t 4e (platinum, palladium, gold and rhodium) from the MSZ | • Second largest reserve after Bushveld.<br>• Large oxide resources<br>• Potential in the LSZ<br>• By products – copper, nickel, cobalt |
| Chrome ore | 10 billion t in 11 seams and eluvium | Largest reserve in the world<br>Metallurgical, chemical, refractory |
| Nickel | Nickel laterites on the northern part of the Dyke | • The most significant of Zimbabwe's mineral resources yet to be fully evaluated<br>• African erosion surface regolith<br>• >2% Ni over a stretch of 100km<br>• What do they tell us about the palaeogeography? |
| Asbestos | Chrysotile asbestos has been mined from only one area, the Ethel Mine north of Mutorashanga. | The fibre occurring in lodes varying from 1.5m to 9m in width is up to 2.5cm long and is of fine quality |
| Magnesite | Produced from serpentinization of ultramafic rocks | Workable deposits confined in the southern part of the Dyke in the Doro Range |
| Gemstones | chalcedonic minerals including agate, mtorolite and chrysoprase | Deposited into fractures by supergene processes |
| Dimension and | Handsome gabbros | Large resources on Umvimeela, East Dyke and Crystal |

# Discovery

- Carl Mauch's 1870 sketch map shows the Dyke.
- The Dyke is also clearly portrayed as an intrusive body on the 1897 Fletcher and Espin map of Matabeleland Province
- Zealley (1912) coined the term Great Dyke "The Selundi Hills and both valleys of the Tebekwe River are occupied by a portion of a large basic intrusion for which the name 'Great Dyke' is suggested" but Wagner (1914) had suggested that the structure was an 'elongated laccolite'.
- It was only with the work of Worst (1958, 1960) that a fully comprehensive account of the Great Dyke was published.
- Podmore (1970), Wilson (1982), Wilson and Prendergast (1989), Prendergast and Wilson (1989), Mukasa (1998), Oberthur et al (2002), etc worked on the various aspects including geochronology, geochemistry and petrogenesis, mineralization, emplacement

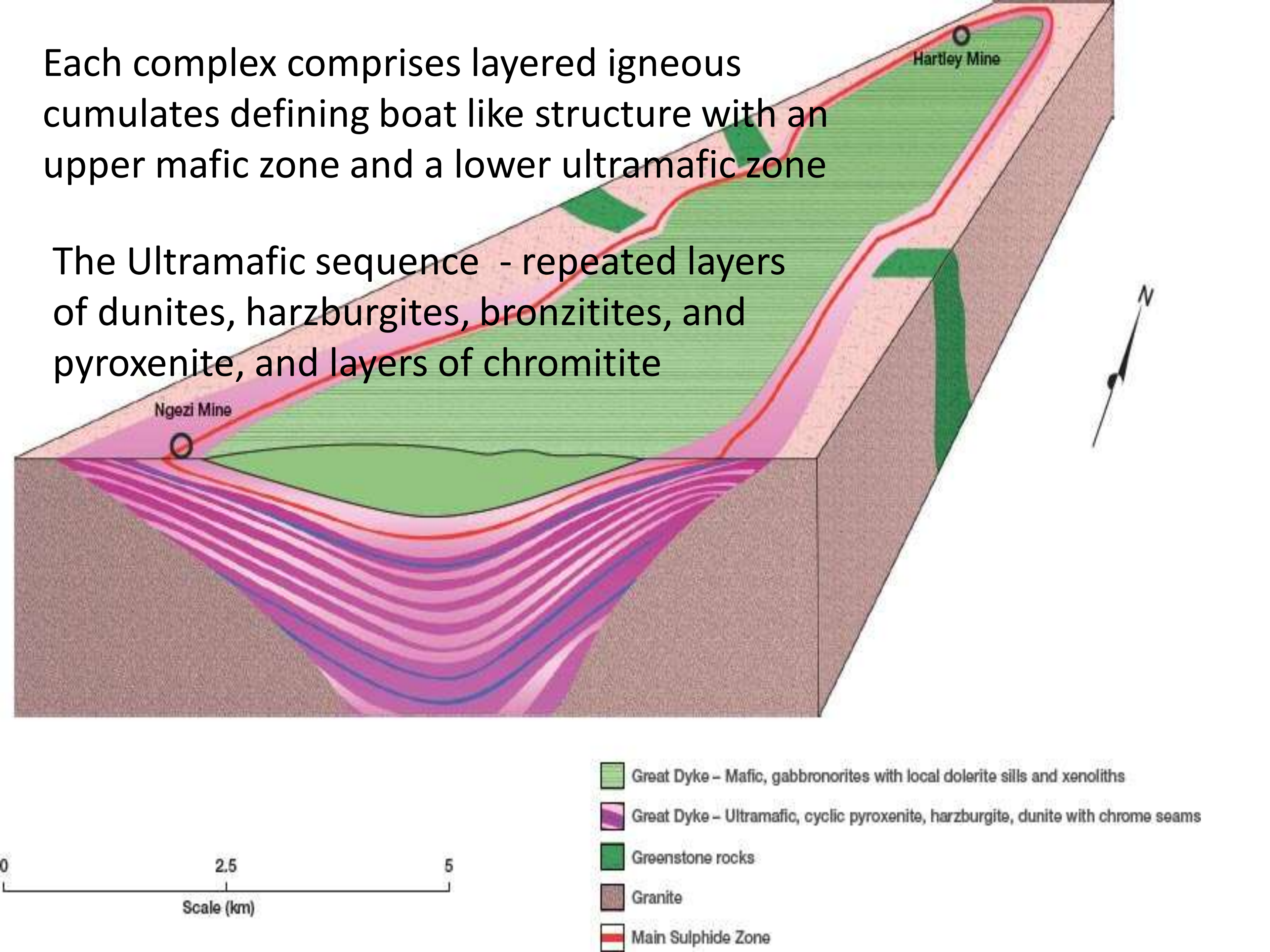
# Early geological observations

- "Several feeders spread along its course" *Lightfoot (1927)*
- "the Great Dyke owes its present size and shape to a zone of weakness similar to those which determined the courses of the Great Rift Valleys of Central Africa" *Keep (1930)* .
- at present erosional surface, comprises five complexes arranged in a straight line and down-faulted in a graben *(Worst, 1958, 1960)*

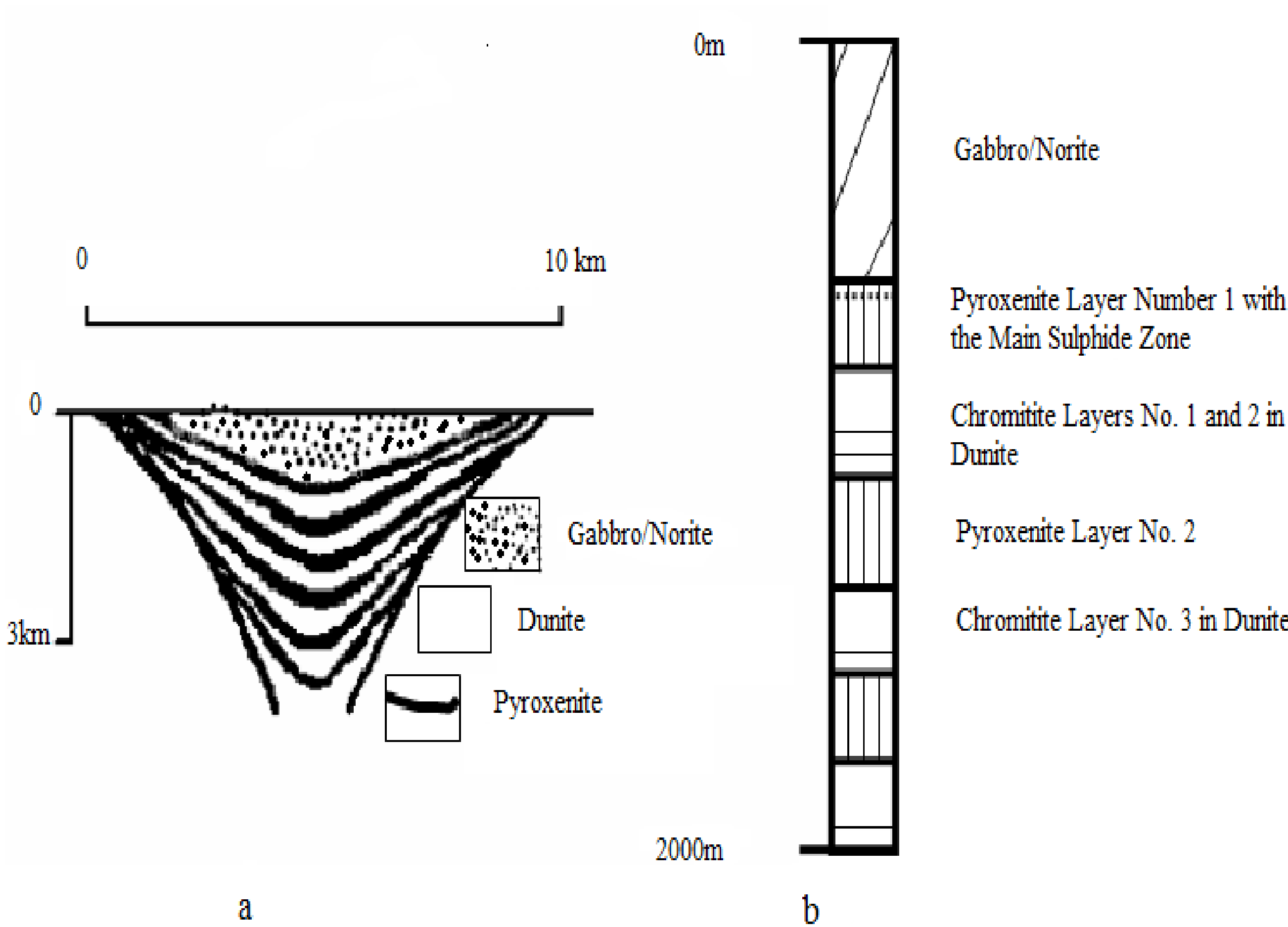


Each complex comprises layered igneous cumulates defining boat like structure with an upper mafic zone and a lower ultramafic zone

The Ultramafic sequence - repeated layers of dunites, harzburgites, bronzitites, and pyroxenite, and layers of chromitite



- The configuration is unusual
- The term dyke has been retained.
- *Worst (1998)* attempted with very little success to rename the structure the ‘Great Graben’.




“The incorrect …term has been applied … since 1908. The term dyke gives a completely incorrect and misleading geological connotation to this world famous geological phenomenon” *Worst 1998*

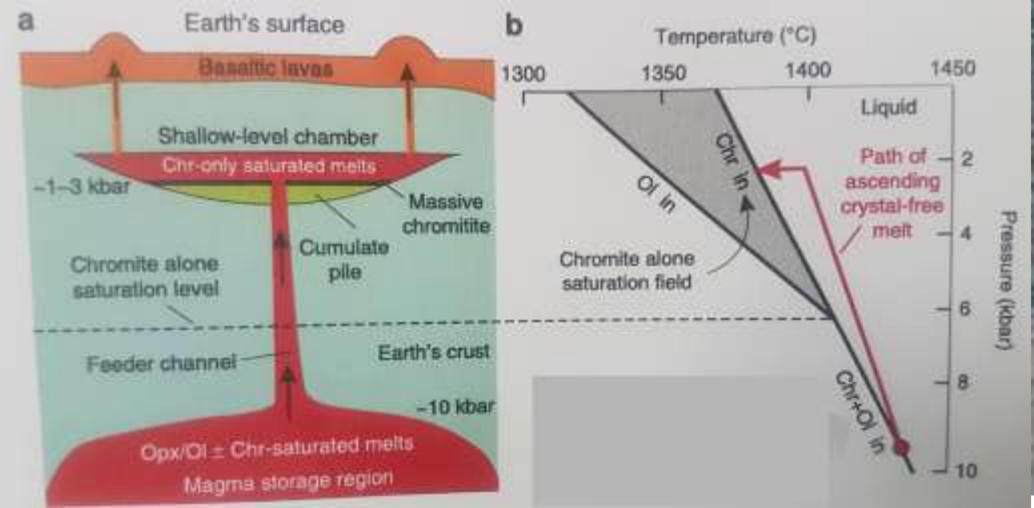
The origin of distinct layers including ore zones (chromitites, Main Sulphide Zone and Lower Sulphide Zone) is is open to debate

- Repeated influxes of new magma into the chamber - Cyclic layers
- Growth of crystals in place or transportation to their positions at the base of magma by density currents
- gravitative fractionation of crystals
- changes in oxygen fugacity and changes in pressure
- crustal contamination;
- magma mixing;
- liquid miscibility;

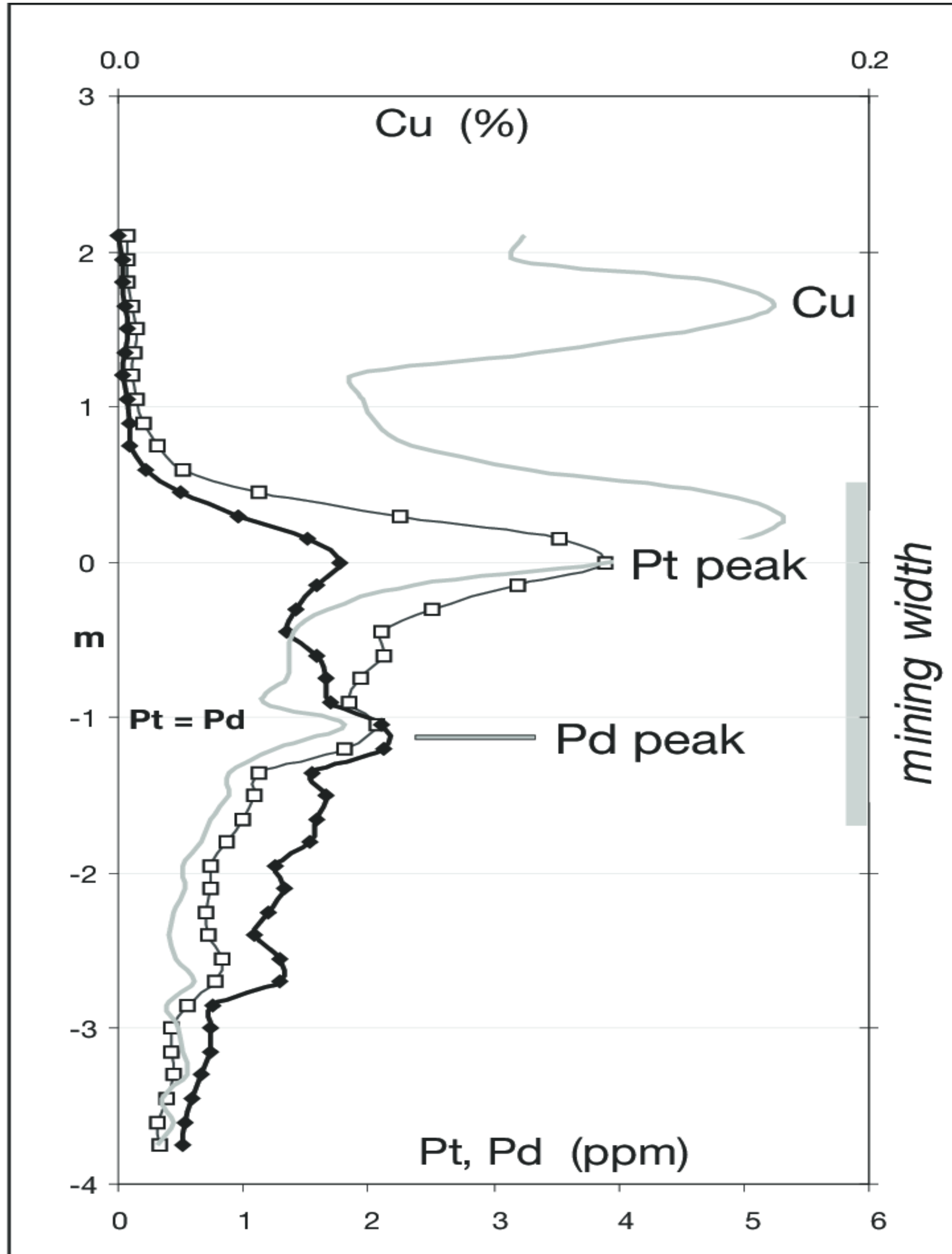
The sharpness of individual layers, especially chromitites casts doubt in the plausibility of these processes

sorting down the slope of gravitationally accumulated layers during chamber subsidence ? (*Maier et al 2013*) Or pressure reduction during magma ascend (*Latypov et al 2018.*

Still no satisfactory explanation to the formation of chromitites *(Lesher et al 2019)*



- Another distinct layer, although not easily observable with naked eye, is the Main sulphide zone (MSZ)
- Found in pyroxenite below the gabbro-norite
- Carries elevated concentrations of PGE, Ni, and Cu in the form of disseminations of sulphides
- Estimated to contain 4.4 Bt PGE ore at an average width of 1.80 m, about 9 % of which is oxidized zone (Prendergast, 1988)
- MSZ is characterized by a typical vertical pattern of base metal sulphide (Cu, Ni, S) and PGE



# Age and relationships

- *Faure et al (1963)* put the age of the Great Dyke at 2110 +-300 Ma using Rb-Sr which age was said to be identical to that of the Bushveld, which supported *Worst (1958)*'s conclusion that the Dyke and the Bushveld were emplaced during the same magmatic event.
- *Robertson and Van Breemen (1970)* obtained an Rb-Sr age of 2533 ±54 Ma
- *Davies et al, (1970)* put the emplacement age at 2532 ± 89 Ma using Rb-Sr
- *Mukasa et al (1998)* obtained 2586 ± 16 using Sm-Nd
- *Wingate (2000)* obtained 2581 ± 11 Ma U-Pb
- *Oberthür et al., (2002)* obtained 2575.4 ± 0.7Ma U–Pb dating of zircon and rutile

- The age of intrusion marks the maximum age of stabilization of the Zimbabwe craton (ZC), as the Dyke transects the entire N-S length of the Archaean granite-greenstone terrane of the ZC and the Limpopo Mobile Belt (LMB).
- The emplacement age of the Great Dyke is taken in Zimbabwe as the upper boundary of the Archaean, which generally corresponds with the internationally recognised boundary between the Archaean and the Proterozoic.
- The Great Dyke has been proposed to be used to mark the boundary between the Proterozoic and the Archaean *(Nisbet 1981)*

**Question??**

- What is the significance of the Great Dyke within the broader context of the ZC given the peak metamorphism in the NMZ at 2591 ± 4 Ma and the widespread Chilimanzi plutonism at 2601 ± 4 Ma??
- Is there a connection between the craton-wide episode of granite formation at ∼2600 Ma and the intrusion of the Great Dyke?
- What about some granites in the craton and the Limpopo Belt with ages that are apparently younger than the Great Dyke *(Jelsma and Dirks, 2002; Blenkinsop, 2011)*?
- Could the Great Dyke magma be the terminating mafic phase of an extensive melting event in the lower crust which gave rise to the Chilimanzi granitoids (2601 +-5 Ma) emplaced immediately prior to the Great Dyke emplacement *(Watkeys et al 1997)* ?.

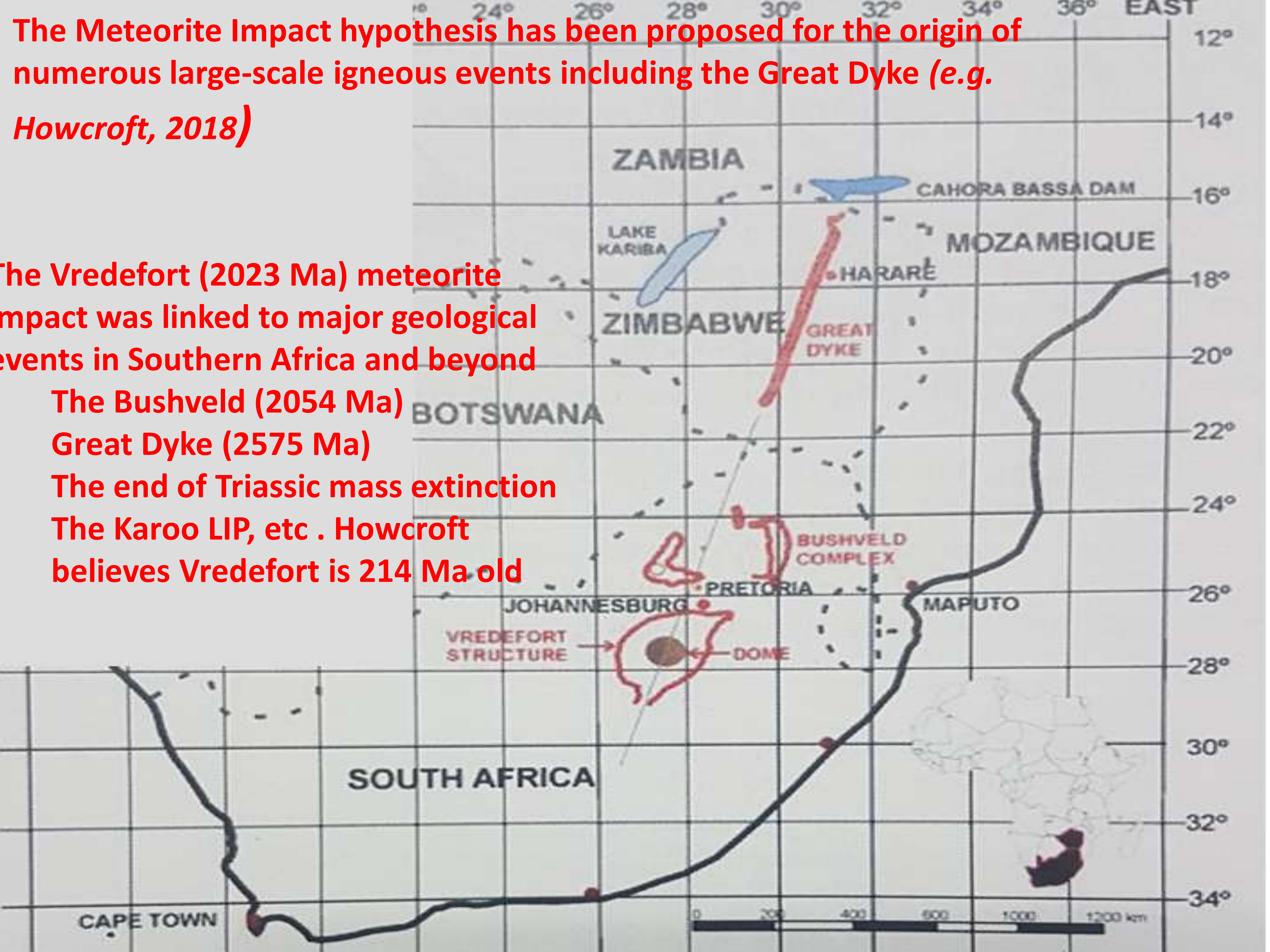
- Could the noritic rocks be inferring derivation from melting of a mantle whose composition would have evolved from prior extensive extraction of mafic magma that formed the greenstone belts characteristic of ZC? *(*Windley, 1973; *Katz, 1985; Srivastarva, 2008)*.

- Does the noritic or boninitic and other geochemical signatures more often associated with magmas at destructive plate margins, suggest that the Great Dyke was formed at subduction zone?
  - related to amalgamation of the Kaapvaal Craton (KC) and ZC*? (Mukasa et al 2000)*
  - or the so-called Munyati Subduction zone? *(Bozhko, 1997)*
- What is the significance of the similarity in the petrogenic and geochemical pathways between the Great Dyke and other Archaean to early Proterozoic complexes? (see Hall et al 1997).

The Meteorite Impact hypothesis has been proposed for the origin of numerous large-scale igneous events including the Great Dyke *(e.g. Howcroft, 2018)*

he Vredefort (2023 Ma) meteorite
mpact was linked to major geological
vents in Southern Africa and beyond

- The Bushveld (2054 Ma)
- Great Dyke (2575 Ma)
- The end of Triassic mass extinction
- The Karoo LIP, etc . Howcroft believes Vredefort is 214 Ma old



**“….shooting a bullet today into the side of a cliff where the strata is 2055 Ma…does not make the bullet 2055 million years old”**
***Howcroft, 2018***

# Hotspot

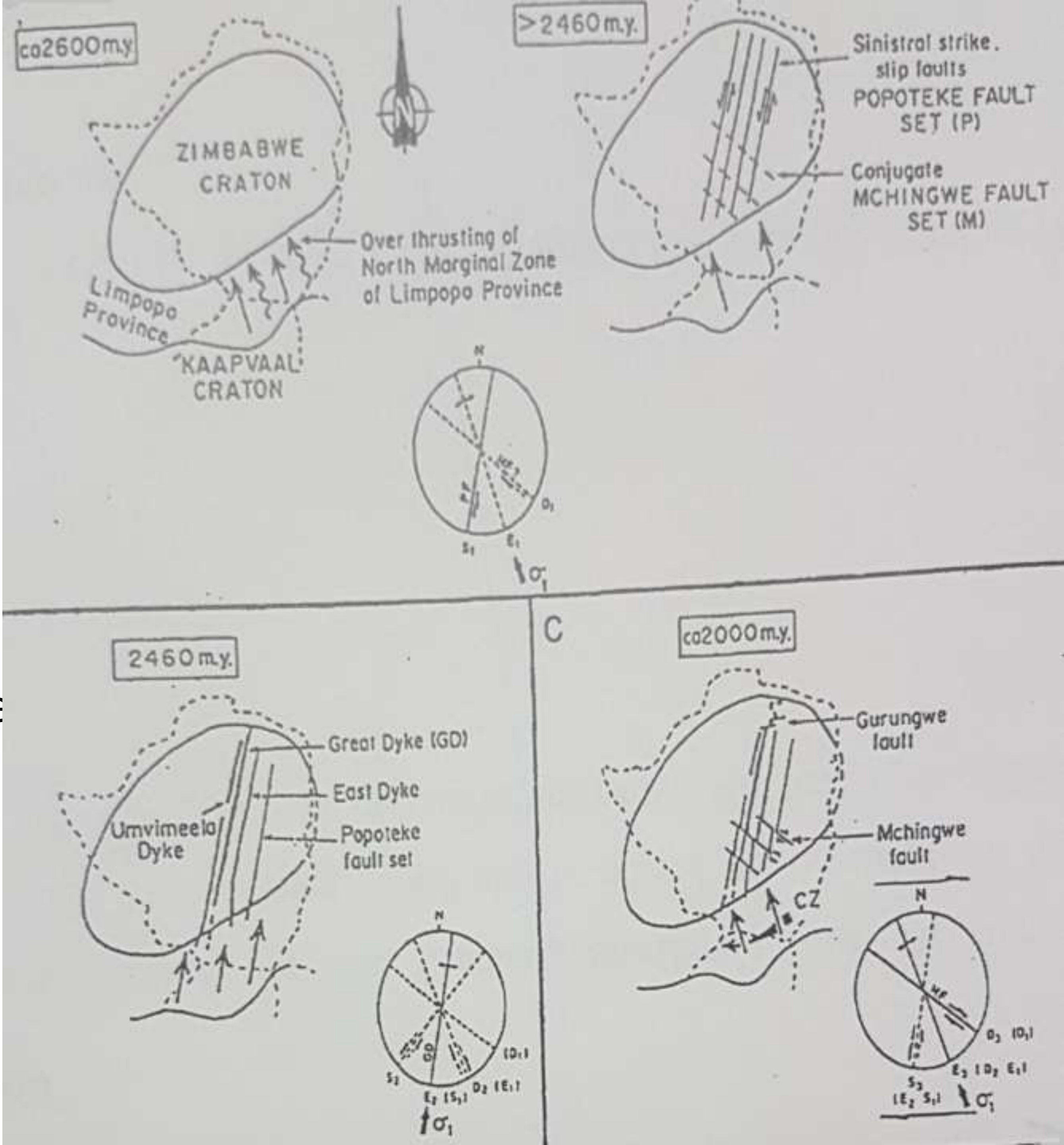
- A hotspot caused a major igneous event, the effects of which are manifested over a vast region encompassing Southern Africa.
- The main or inner complex of the igneous event is represented by the Bushveld Complex while the Great Dyke and other minor intrusions form geographically detached Satellite or Outer Complexes *(Hall,1932)* .

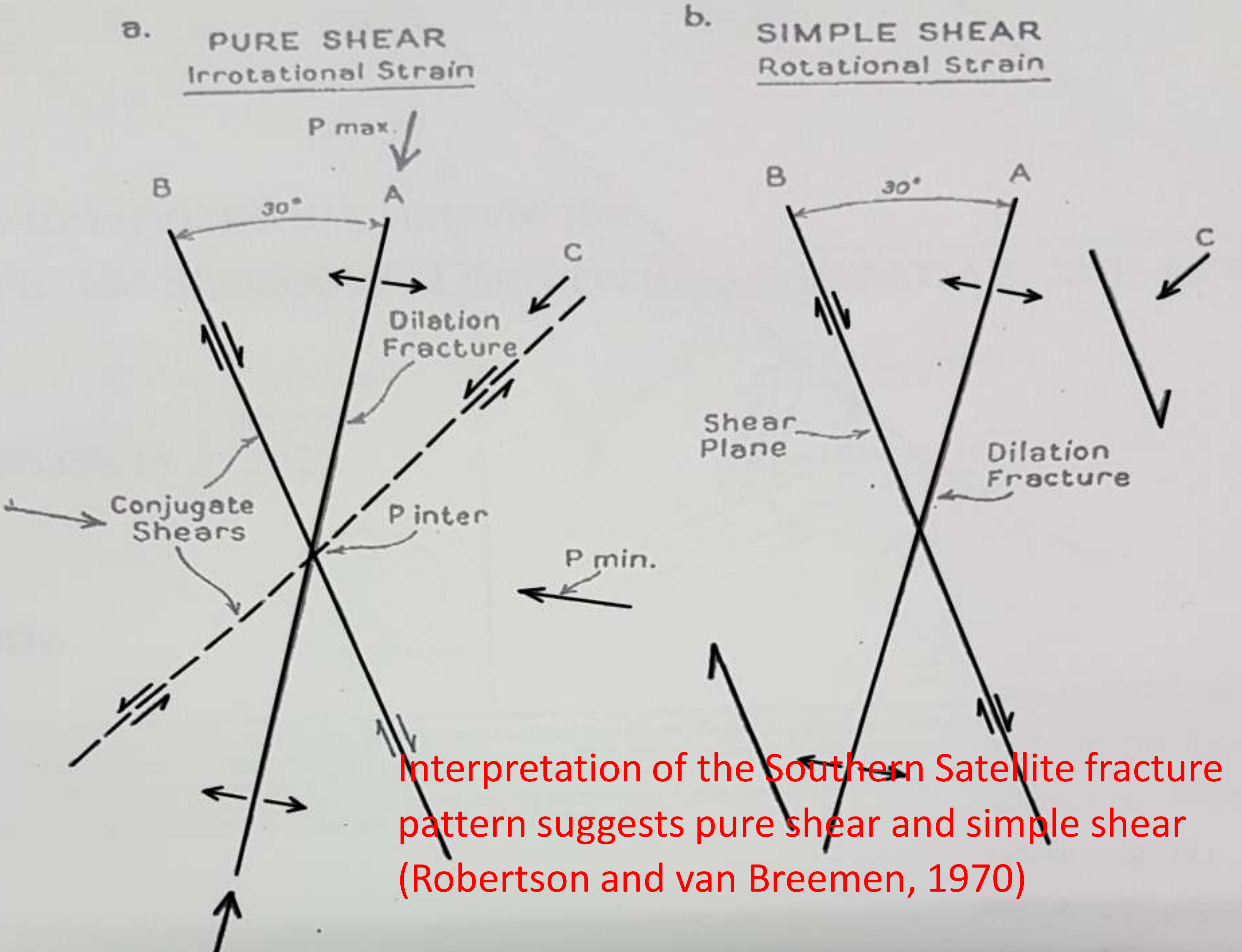
# Mantle Plume

- Remnants of an Archaean LIP linked to the normal processes of the evolution of the Earth's crust? *(Headman, 1997; Bleeker, 2003)*
  - The margins of the Great Dyke probably extended beyond its present confines and may also have propagated to the surface to form an extensive flood basalt province which has now been completely eroded.
- LIPs become difficult to identify because typically the volcanic component has been eroded away leaving only the intrusive component including dykes, sills and layered complexes.
- The Great Dyke is therefore probably a manifestation of an ancient Large Igneous Province (LIP), which makes the Great Dyke the world's oldest failed rift system?

# Collision induced Fracturing

The Great Dyke is occupying a rift caused by the incipient breaking up of the Zimbabwe craton responding to the collision with the Kaapvaal craton in the late Archaean time *(Katz 1985; Wilson, 1990; Robertson and Van Reemen 1970)*



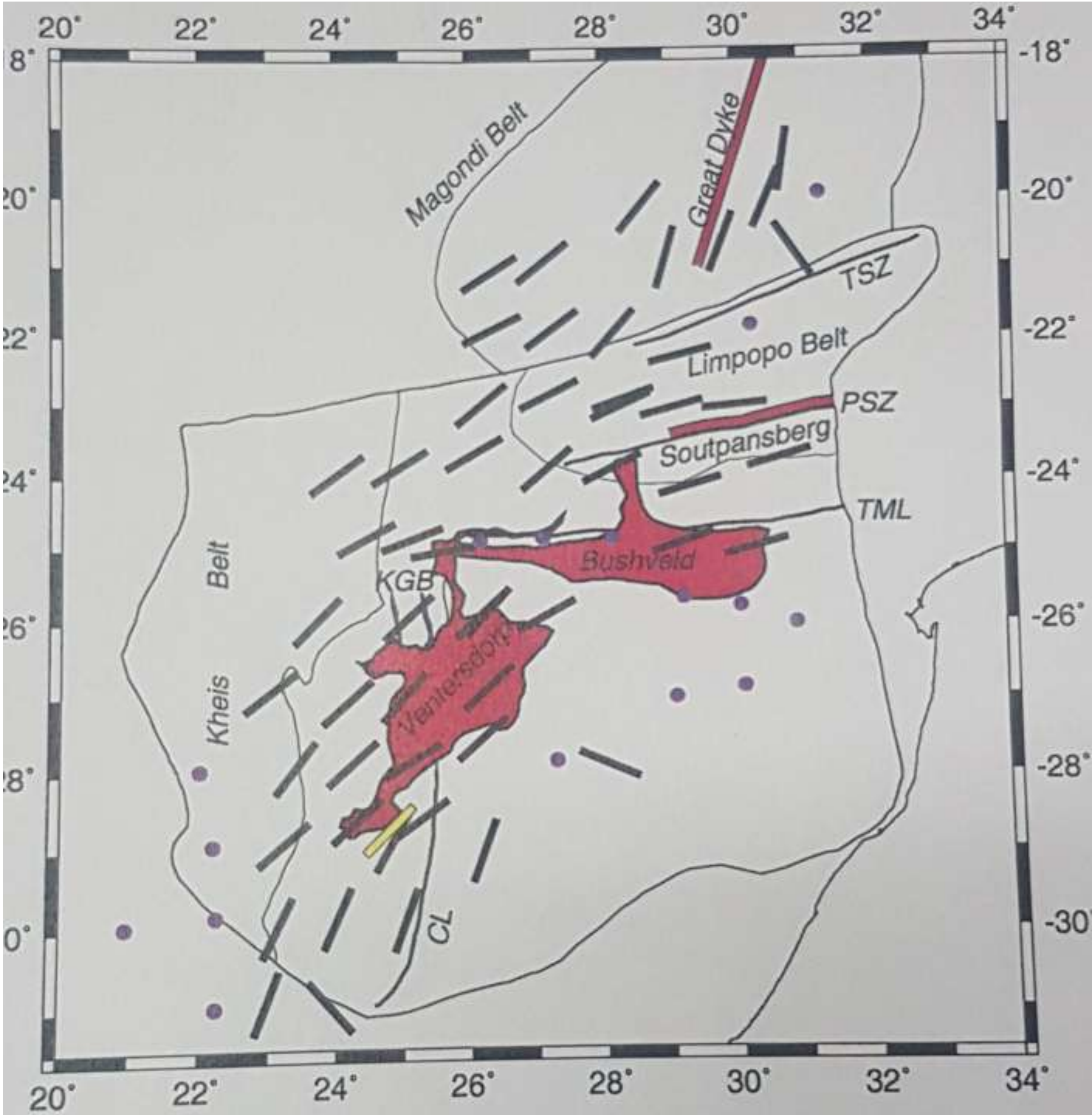



Interpretation of the Southern Satellite fracture pattern suggests pure shear and simple shear (Robertson and van Breemen, 1970)

Seismic anisotropy studies of Southern African crust show that the Great Dyke and the Bushvwld occupy pre-existing structures *(Silver et al 2004)*,

Convergent tectonic settings at high/oblique angles to these structures would have created high dilation

Thus both intrusions had tectonic triggers, and may not be related to deep mantle circulation patterns



The Great Dyke is accompanied by true dykes, the Umvimeela and East Dykes to the west and east respectively

To the south is another group of true dykes collectively known as the Southern Satellite dykes

Structural, petrological, palaeomagnetic, Geochemistry and geochronological evidence suggest that the Great Dyke and its satellites are  genetically related.

The Chimbadzi Hill lying about 50km to the west of the Dyke has been considered to be a satellite dyke (Worst, 1960), but is now dated at 2262 Ma (Manyeruke et al 2004)

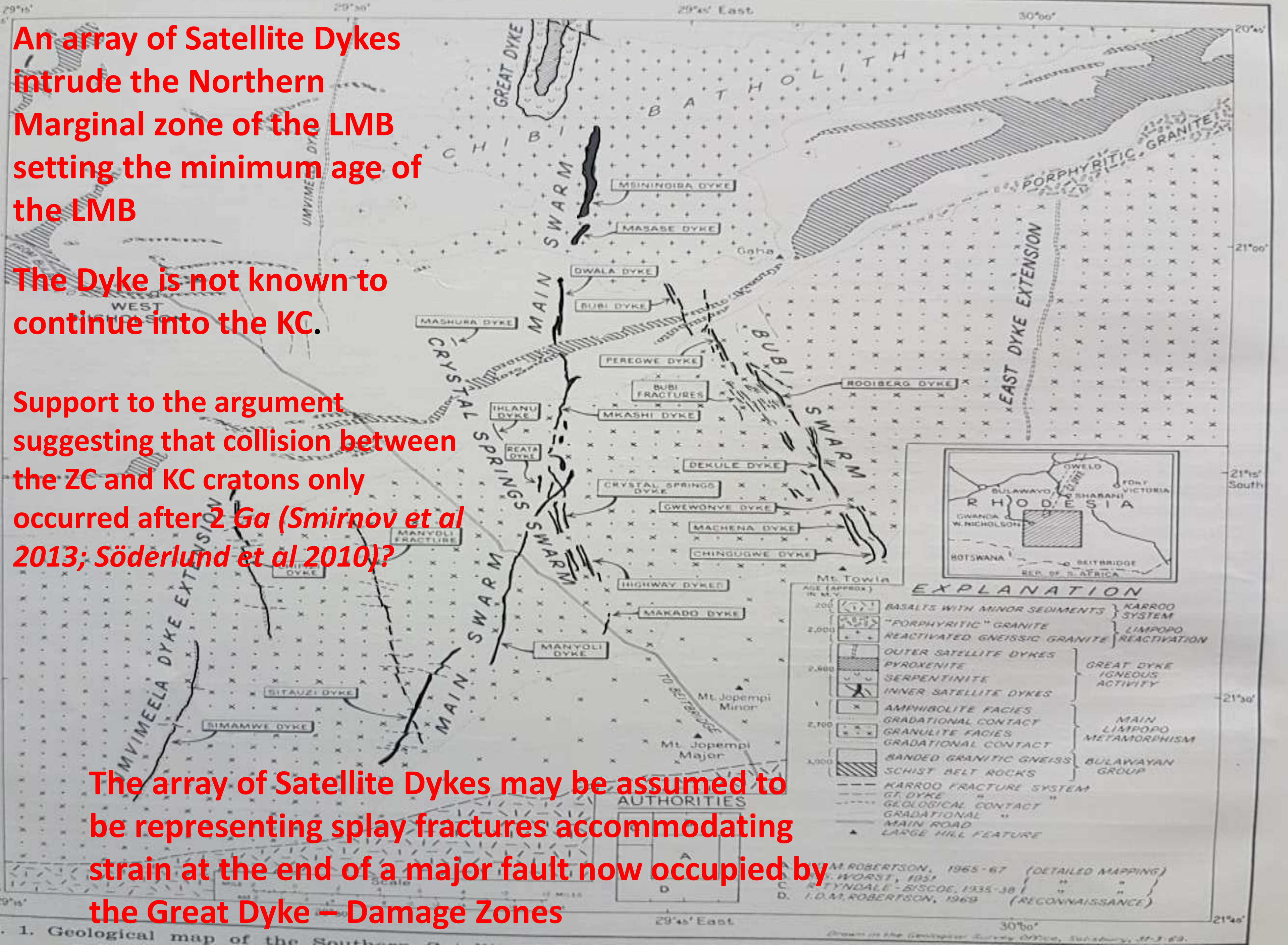
**What happens at the southern tip of the Great Dyke**

An array of Satellite Dykes intrude the Northern Marginal zone of the LMB setting the minimum age of the LMB

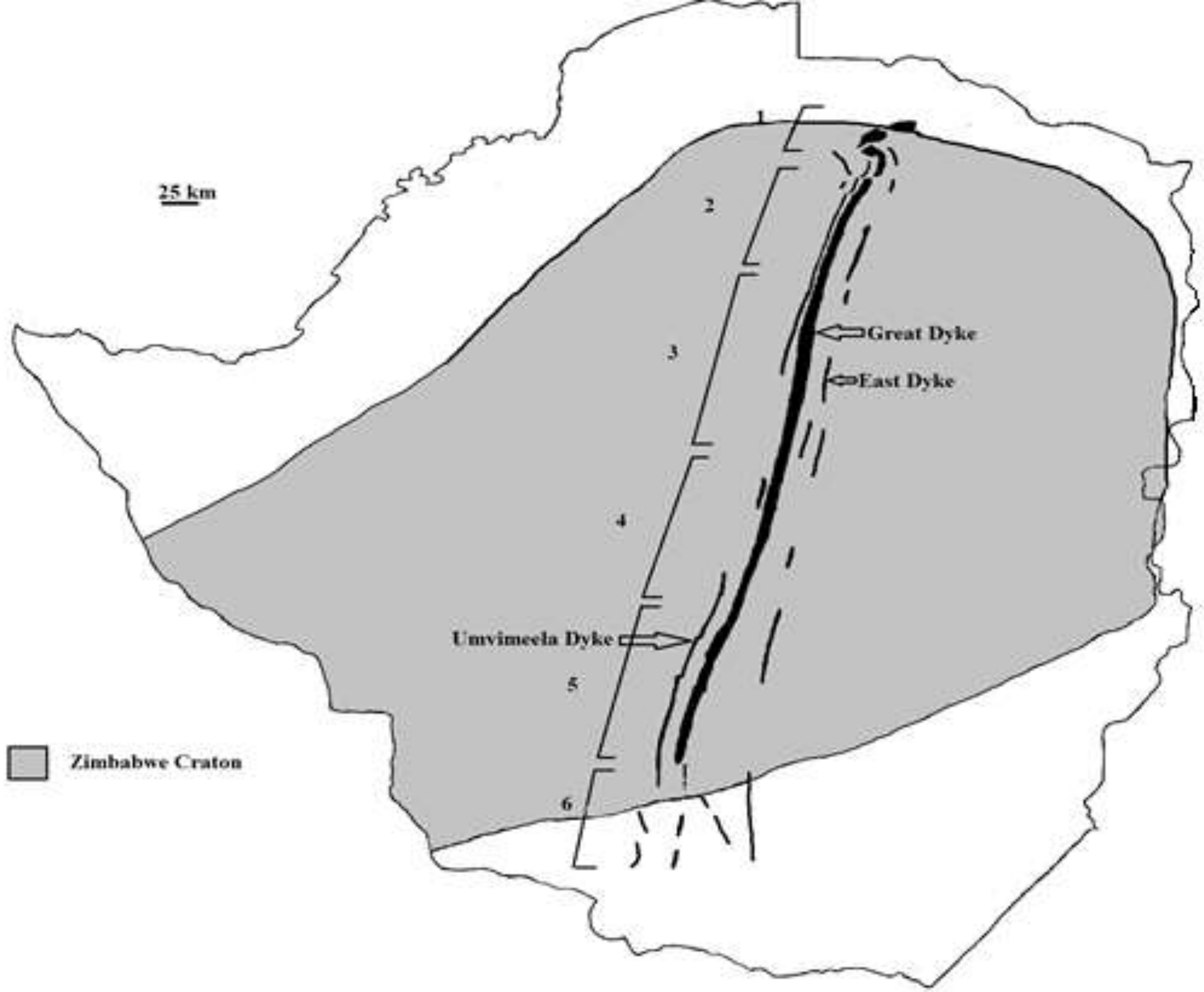
The Dyke is not known to continue into the KC.

Support to the argument suggesting that collision between the ZC and KC cratons only occurred after 2 *Ga (Smirnov et al 2013; Söderlund et al 2010)?*

The array of Satellite Dykes may be assumed to be representing splay fractures accommodating strain at the end of a major fault now occupied by the Great Dyke – Damage Zones



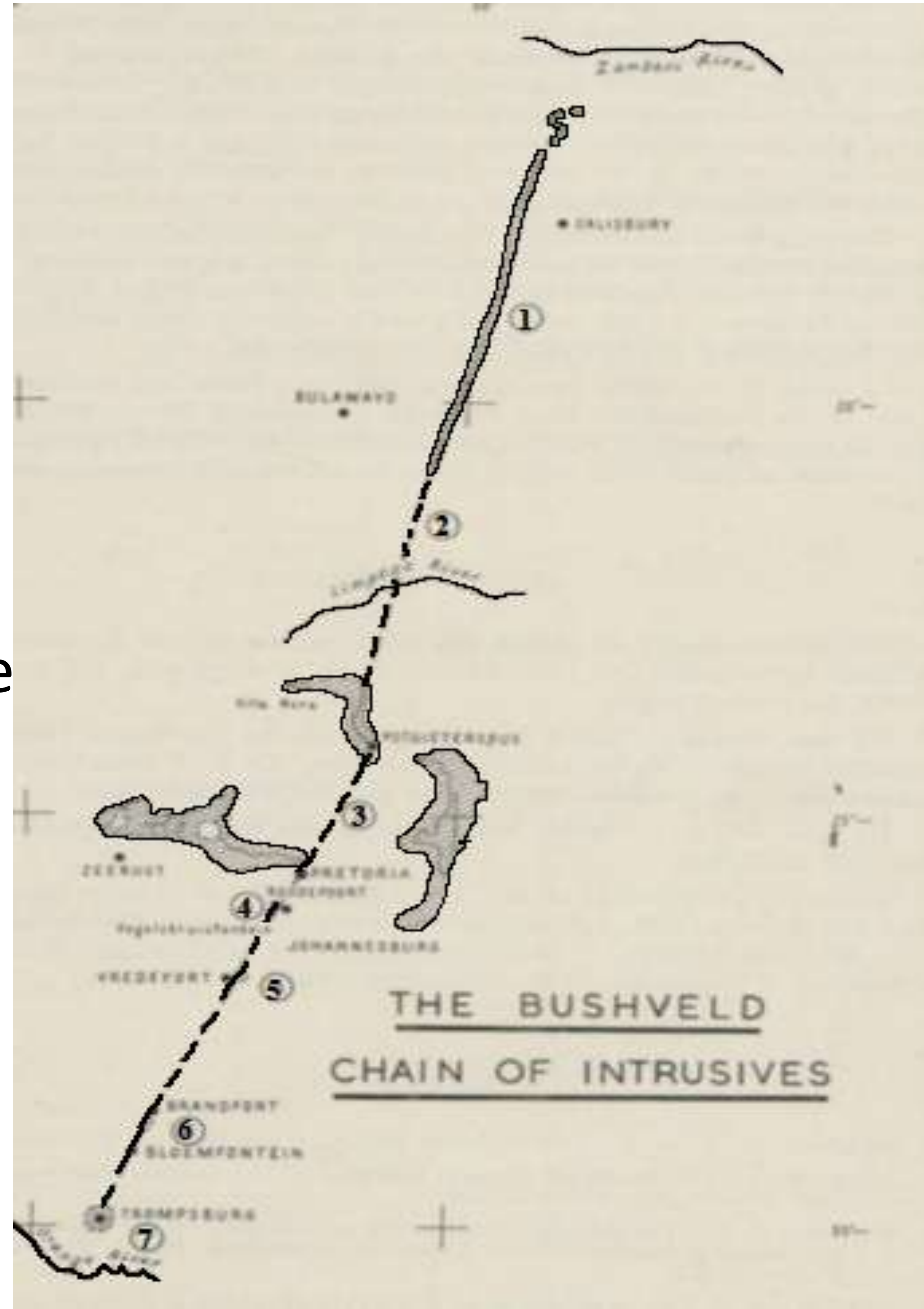

1. Geological map of the Southern ...




The Southern Satellite Dykes extend southwards for about 85 km from the southern end of the Great Dyke. They cut the NMZ and are apparently unaffected by deformation or metamorphism. They determine an upper limit of the age of high grade metamorphism and folding in this part of the Mobile Belt

There have however been many attempts to link the Great Dyke to the Bushveld and other complexes despite the vast differences in ages - stretching 1500km from the Zambezi to the Orange River

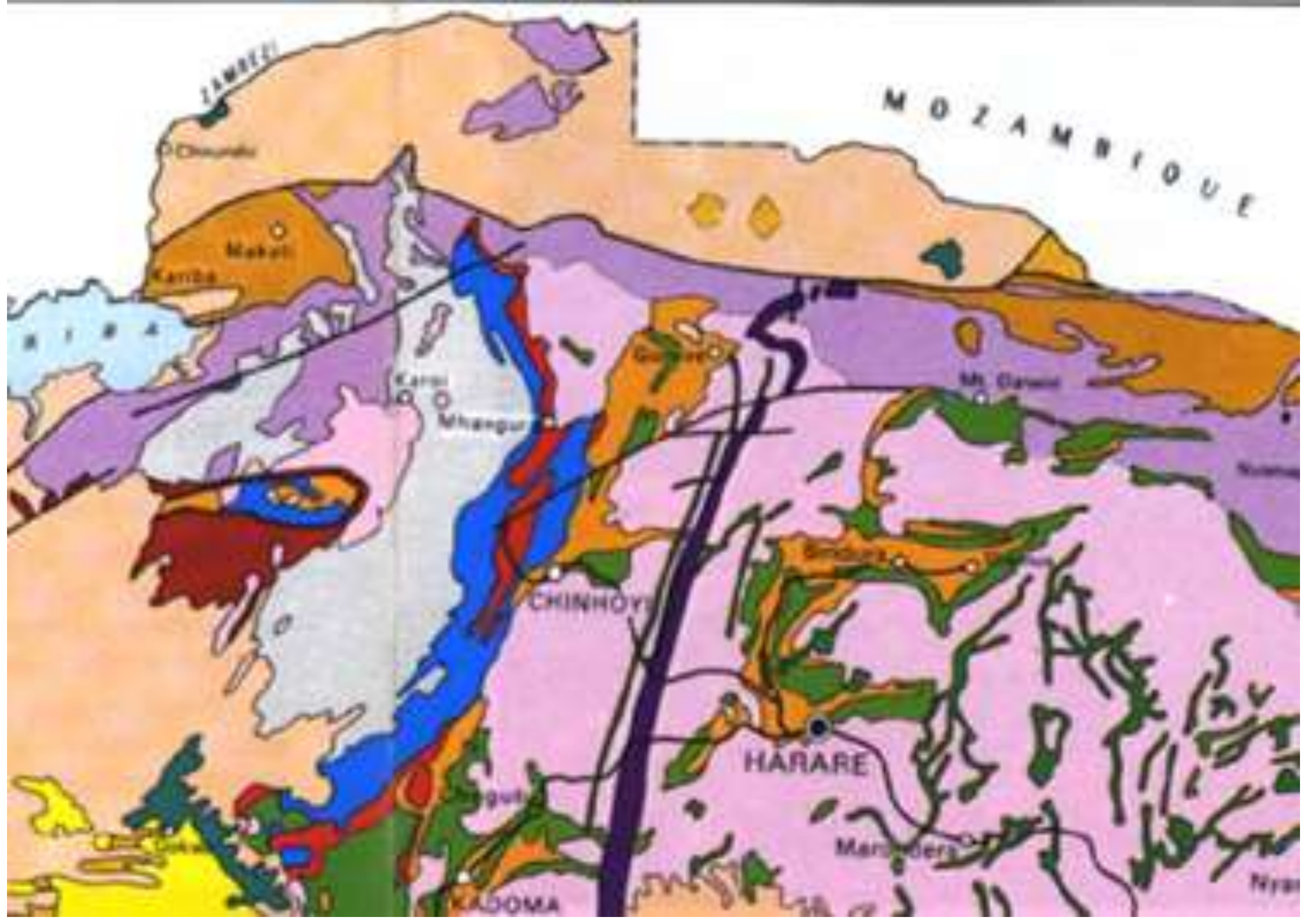
The “Bushveld Chain of Intrusives’ (Cousins (1959).



# What happens to the northern end of the Great Dyke

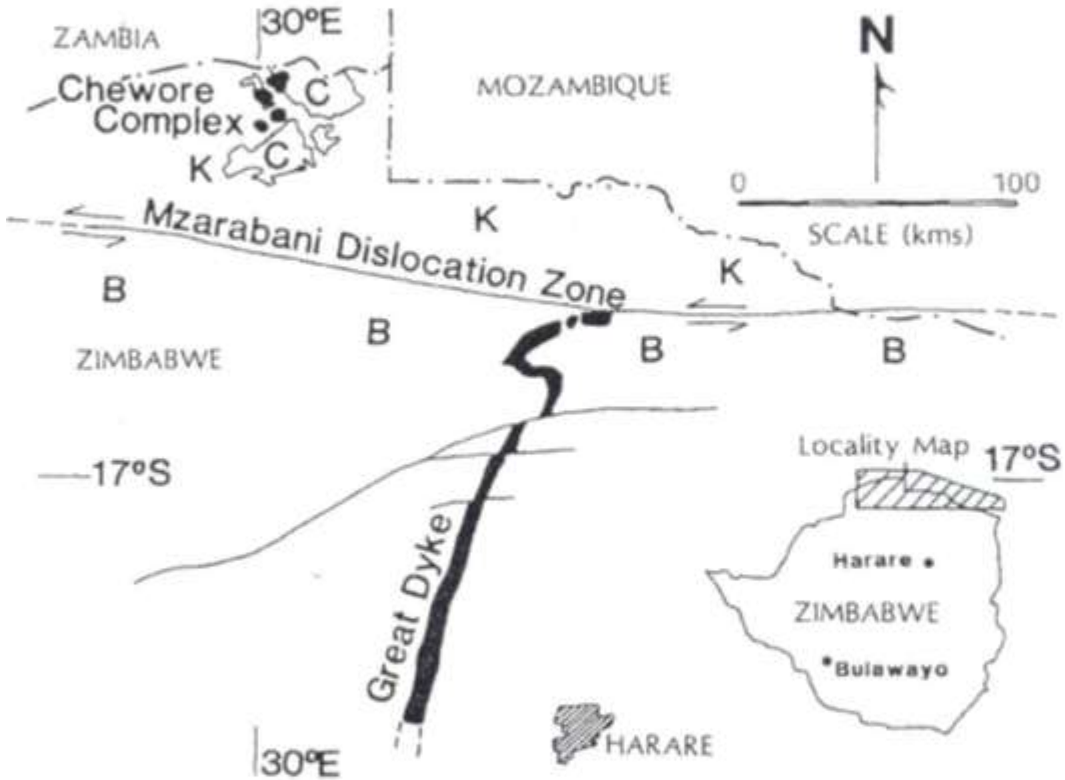
The northern end of the Dyke is not so clear but it cuts across penetrative cleavage, which suggest older orogenic zone predating Pan-African deformation *(Vinyu et al 2001 Wiles, 1972; Prost, 1982; Chimbodza, 1987; Chiyanike, 1987)*.

The Pfunzi Belt




The Dyke is thrusted southward and tilted corkscrew style by the Pan African Zambezi Belt, and also probably downfaulted by the Karoo age Muzarabani Fault.

While it may look like the Snakes Head marks the northern extremity of the Dyke, there are possibilities that the Dyke continues northward below the Karoo *(Mtetwa 2002)*.




A genetic relationship between the Great Dyke and the Chewore Ultramafic Complex 130km NW of the northern end of the Great Dyke, has been suggested *(Orpen et al 1989; Wiles 1960; Worst, 1960*)

- The layered and lopolithic Atchiza complex in northern Tete Province was once interpreted as an extension of the Great Dyke (*McConnell, 1974*) given the setting along the Great Dyke strike, the geology, and mineral composition.

- The Atchiza complex has now been dated at 864 Ma (*Mänttäri, 2008*)

- The coincidental alignment of the Great Dyke and the East African Rift Valley has led some scientists to speculate that the two may be genetically related *(e.g. Giessen 1936 and McConnell 1972)*
- The difference in ages is considered in this theory to be simply reflecting the long and protracted period of the formation of the Rift Valley - The nature of deeply seated lineaments is still not properly understood. These structures could be surface manifestations of deeply seated NNE trending structures whose reactivation at different geological times manifests as different structures of different ages

- The significance of the northern extent of the Great Dyke lies in the determination of the extent of the Zimbabwe craton
- If the late Archaean fractures hosting the Great Dyke extended the length of Africa as inferred by this theory, then much of the African crust must have been once underlain by an Archaean crust related to the Zimbabwe Craton.
  - This may be difficult to comprehend but invokes the debate of whether there was one large Archaean crust that was later destroyed by orogenesis and rifting *(see Kröner, 1976, 1977*); But the Chewore 'Ophiolites' suggesting an ocean between Congo craton and ZC at 1393 Ma?? (Johnson and Oliver, 2000)

# Conclusive remarks

- The evolution of the Great Dyke, a world-class layered igneous complex with vast resources of PGMs and chromite over 2 570 Ma ago through processes that are still not well-understood, will continue to mystify geologists for many years to come.
- The evolution of the Dyke appears to have been a fundamental process of the growth of the early crust, hence to understand it, one has to holistically study the whole process of the evolution of the Archaean crust.
- The Dyke provides opportunities for studying many subjects related to evolution of the crust including magmatic differentiation processes and assimilation within the crust, as well as related ore-deposit formation processes.
- The relationship between the Great Dyke and other structures such as the Bushveld and the EARS that lie along the same strike cannot be simply discounted on the basis of differences in ages given the growing evidence of mantle anisotropies that may be occasionally triggered into geological activities by crustal events “old faults never die”
  - The nature of deeply seated lineaments is still not properly understood. These structures could be surface manifestations of deeply seated structures whose reactivation at different geological times manifests as different structures of different ages
- With the huge mineral resources, enormous size, and enigmatic evolutionary history, the Great Dyke is truly a geological wonder full of treasures and mysteries, and will continue to bewilder generations of geoscientists.


Thank You
BEERS BLOCK
THE SPRINGS
BANNOCKBURN
Mtishanga
SANDEMANS FARM
LOT 1
EMHONGONDOLE
Mudongori
WEDZA
WEDZA BOREHOLE
Rusvinge
Mazangari
Rukwenga
Chemsodzi
Ture Ya Wedza
Wedza School
Bannockburn Station
VERY POOR EXPOSURE
Musenewara
Gwamatoro
Nduri
G
Gp
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P1
P2
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