The Limpopo Belt in Zimbabwe as a geological heritage

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Contents

Introduction and Background

Geology and the earth's history

Certain geological features exhibit different degrees of scientific importance :

- Bodies of unusual rock types
- Landforms that preserve records of the past
- Significant fossil localities
- Stratigraphic type sections
- Areas where significant advances in geology were made
- Deposits of particular minerals

These geological features are important to current and future generations to understand the Earth

Such important features form part of any country's **geoheritage** and can be considered to be **geoarchive**s

Calls for treating such geoarchives as endangered species are growing louder.

Geoheritage is important for natural resource management, land management, research, education, and tourism in many developed countries.

Geoheritage sites are scale independent

- What is important in geoheritage is the enumeration of arguments for designating a particular feature a heritage

Geoheritage in Zimbabwe

No legislation, nor any formal systematic process for the identification, conservation and management of sites of geoheritage.

Current efforts, which hopefully are a precursor to eventual establishment of a more systematic approach to identification of geoheritage sites for preservation:

- GSZ's programme of atlas of interesting outcrops;
- **Broderick and Hubbard** on Matobo Hills, **Master** on Chimanimani Mountains, and **Mugumbate** on Chinamhora Batholith, *In* '**Africa's Top Geological Sites**' 2016;
- **Mugumbate (2024)** Belingwe Greenstone belt article published in a Special Publication of the Geological Society of London 'Geology's Significant Sites and their Contributions to Geoheritage'

The LMB

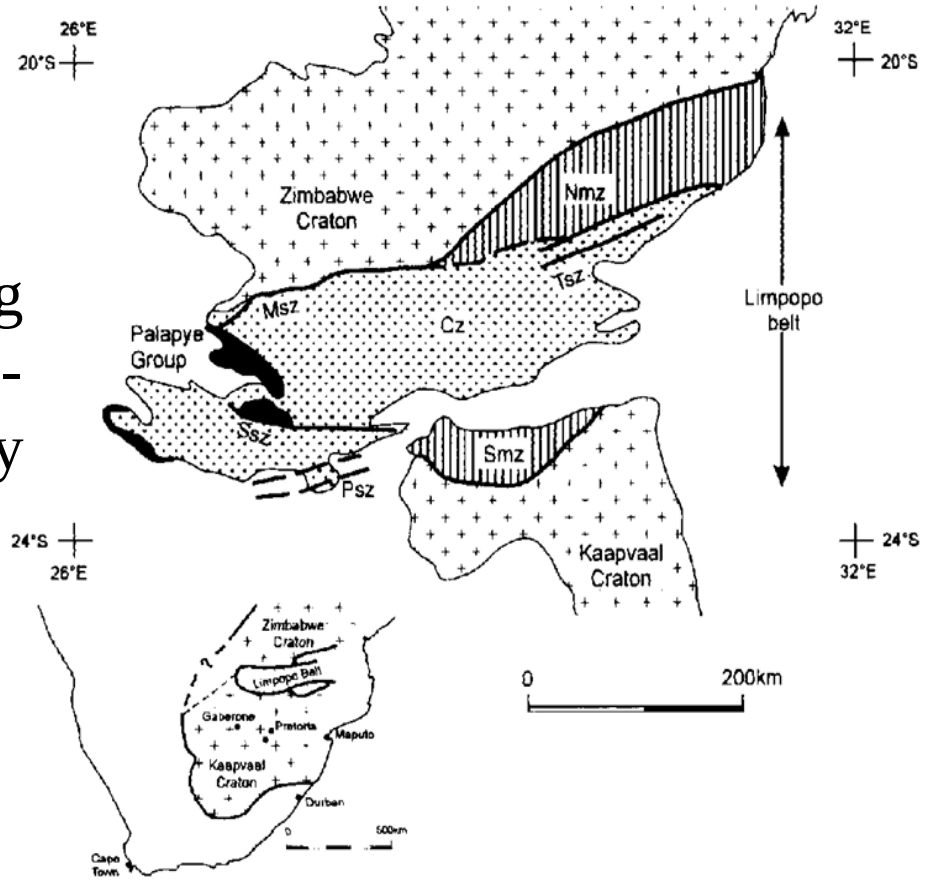
First recognised by MacGregor (1953) - coined the term ‘Limpopo Orogeny’

A distinct zone of high grade metamorphic rocks striking ENE for about 700 km, separating the Archaean granite-greenstone ZC to the north from the KC to the south by over 250 km

Continues to attract interests of many geologists since its discovery as one of the oldest granulite terranes in the world

But why are such terranes rare?

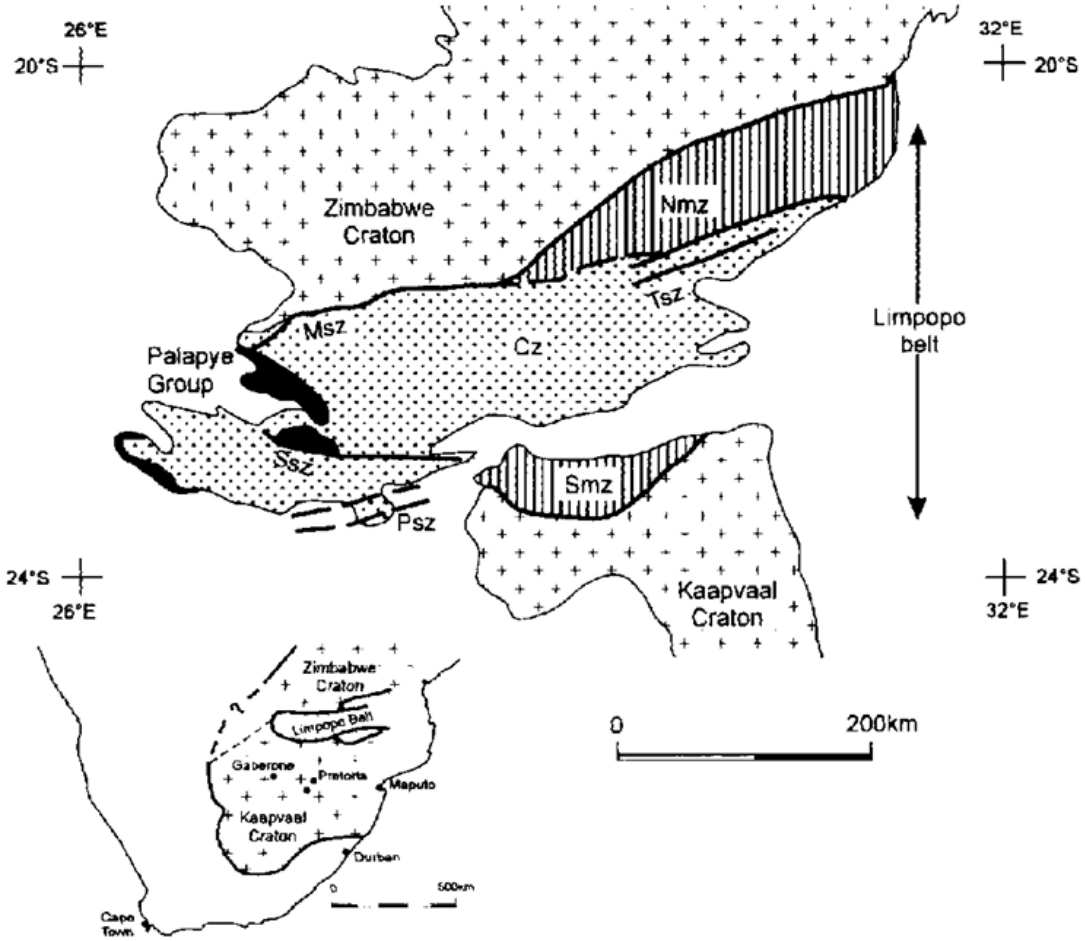
The nature and tectonic evolution of the LMB remains topical.



Geology

Two marginal zones, the Northen Marginal Zone (NMZ) and the Southern Marginal Zone (SMZ) flanking the Central Zone (CZ)

- all at granulite-facies grade



McCourt and Armstrong 1998

The NMZ bordering the Zimbabwe craton is easily distinguished from the later terrane

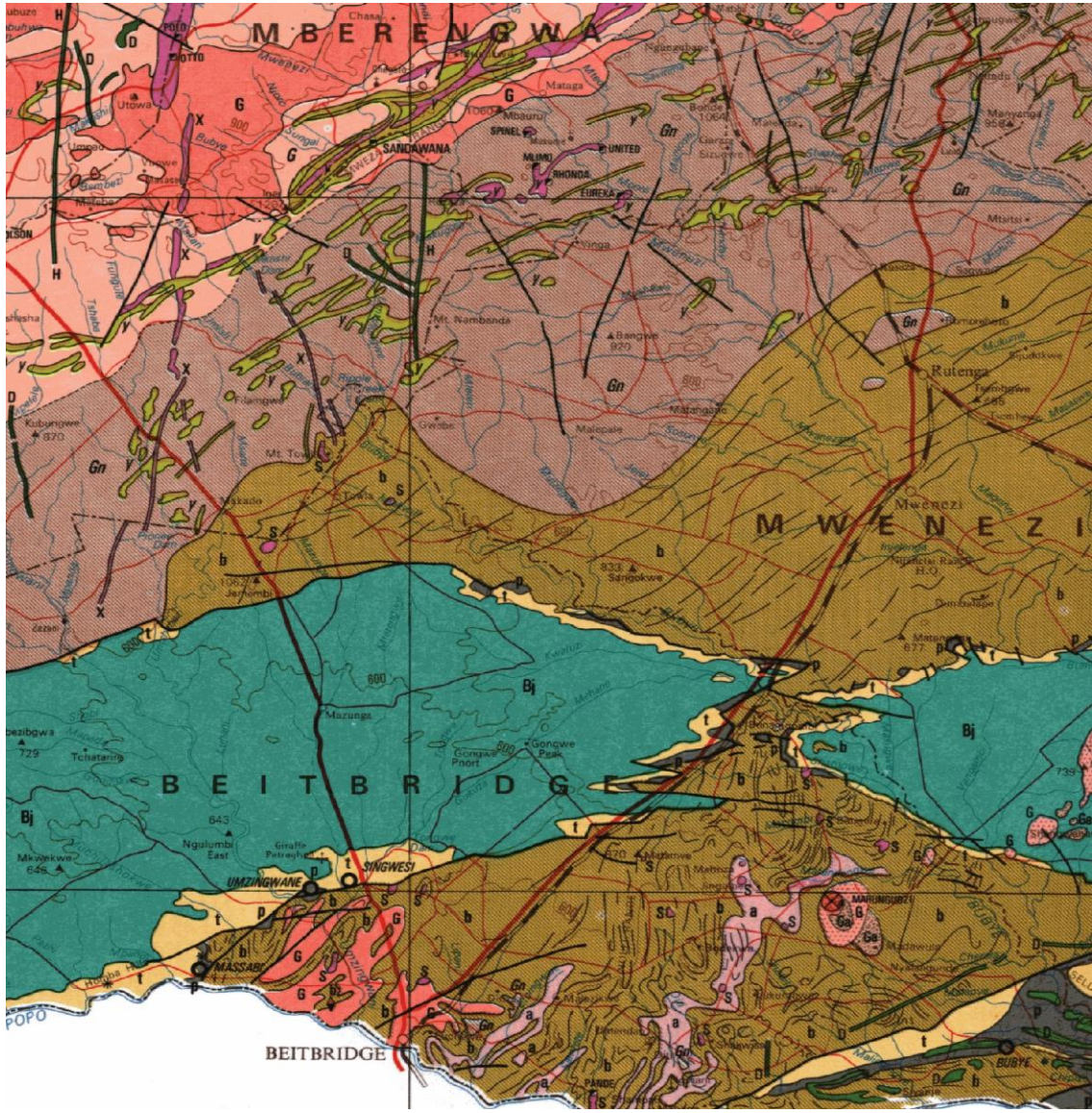
granulite facies metamorphic rocks, isoclinal and sheath folds showing high strain

The Central Zone

Dominantly supracrustal rocks manifesting as paragneisses.

Differs from the marginal zones both lithologically and structurally.

While structural trends in the Marginal Zones are dominantly ENE, they are mainly N-S in the CZ.



Age of the LMB

Extensive geochronological studies over 5 decades generally show age data defining three main age clusters.

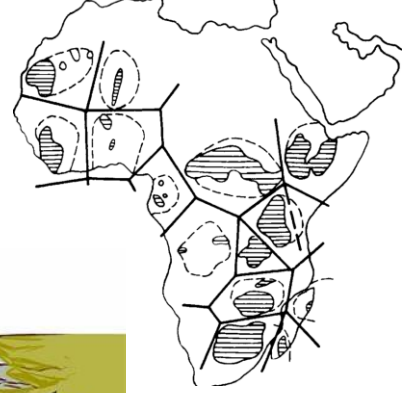
The oldest, at ca. 3.3 Ga, exists in the CZ and SM – defined by magmatic zircon dates

The second, between 2.7 and 2.55 Ga, occurs in all three zones - dated mainly by zircon U-Pb, associated with intense deformation, high grade metamorphism, and widespread anatexis,

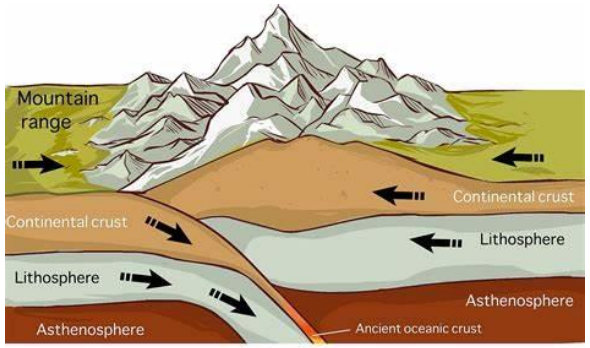
The third cluster is 2.0 Ga in all the three Zones - associated with high grade metamorphism

The evidence for both Neoarchean and Paleoproterozoic ages, both defining high-grade tectono-metamorphic events, has led to controversies as to the age of the orogenic belt

Some debate about the tectonic origin



Ensialic remobilization of an Archean supercontinent (*McElhinny andMcWilliams 1977; Katz 1985)*



Continent – continent collision

simple collision between the Kaapvaal and Zimbabwe cratons during Himalayan type plate tectonics during late Archaean (*Shackleton 1995; Light 1982 and Roering et al 1992; Rollinson et al 1997; Kampunzu et al 2001*)

Accretion of multiple exotic and unrelated terranes at 2.65 Ga (*Watkeys 1984; McCourt and Vearncombe 1992; Barton et al 2006)*

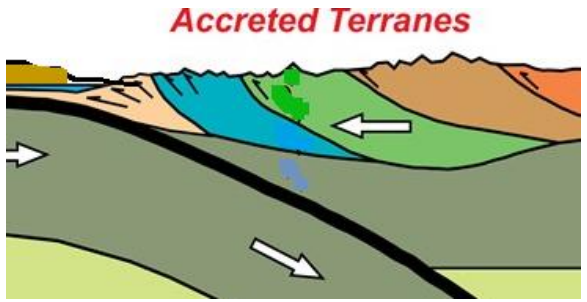
These models suggest that the ZC and KC were a single plate at ~ 2.7 Ga

The 2 Ga Puzzle

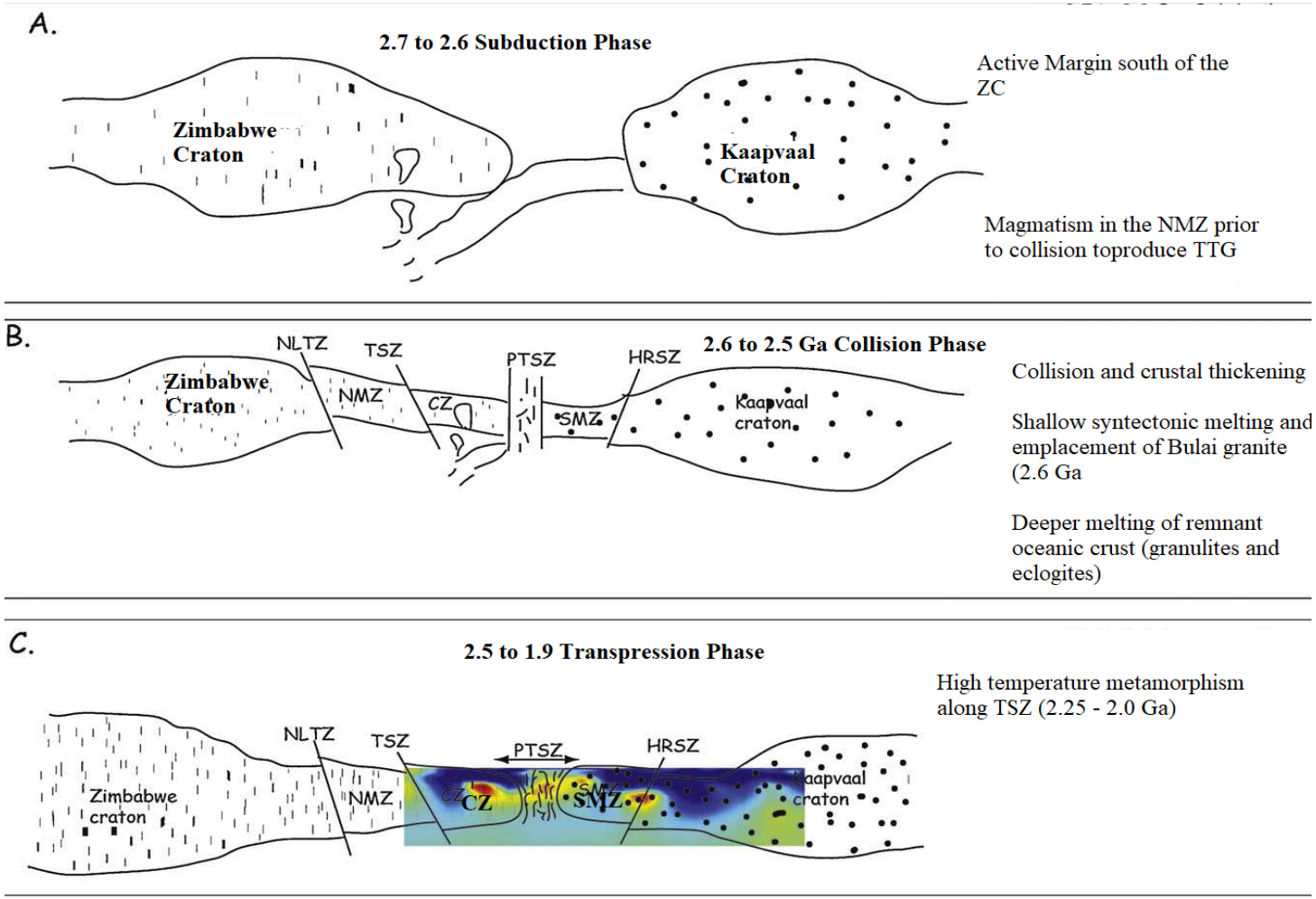
The significance of the 2 Ga Proterozoic event remains obscure.

The problem is compounded by the fact that the Proterozoic structures in the northern part of the NMZ were apparently identical to the late Archaean structures (*Blenkinsop et al., 2004*).

The NMZ, CZ and SMZ are considered to be exotic terranes of unrelated origin accreted over a protracted period of time between 2.7 and 2.04 Ga (*Barton et al 2006*)



Integration of geochronology, geophysics, and metamorphism suggest a model that involves (1) subduction phase at 2.7–2.6 Ga, (2) collision phase at 2.6–2.5 Ga and (3) transpression phase at 2.2–1.9 Ga *(Barton et al 2006; Khoza et al 2013*)



These of continent to continent collision with a full closure of sea however remain speculative without unequivocal proof of ophiolites and convincing evidences of subduction

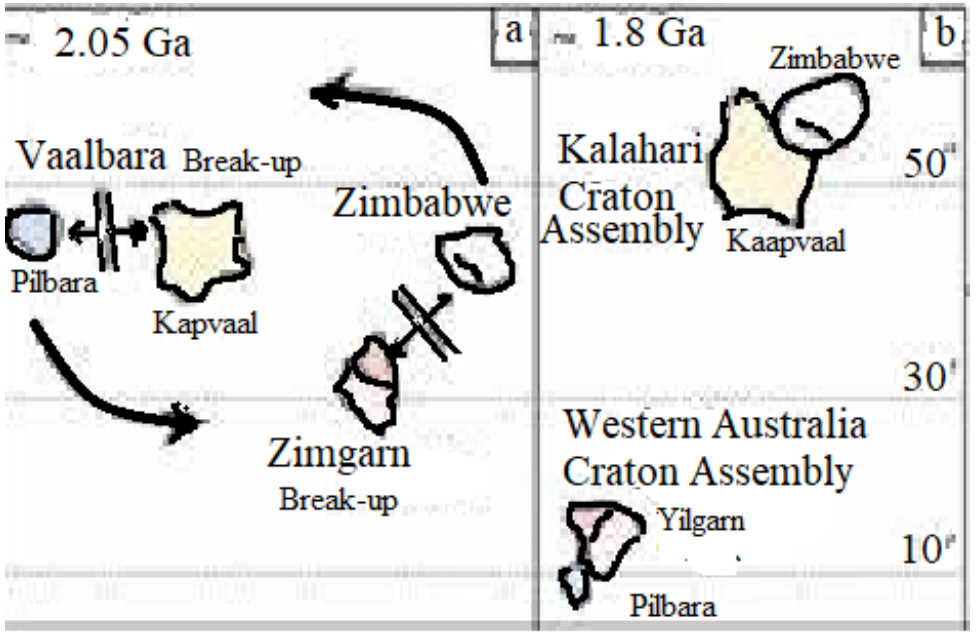
Studies of LIPs are helping to decipher the evolution of the Zimbabwe and Kaapvaal cratons, and the LMB

Coeval magmatic activity in both cratons took place at 1.9 Ga, (*Söderlund et al 2010*).

Accordingly, the ZC and KC only came together after 2 Ga, which explains the 2.0 Ga age in the LMB

Kaapvaal and Zimbabwe cratons were not in proximal positions in the Neoarchean

The ZC was linked with the Slave Craton and the Yilgarn craton during Archaean, and only amalgamated with the KC after 2 Ga (*Bleeker 2003; Söderlund et al 2010; Prendergast and Wingate 2012; Smirnov et al 2013*)

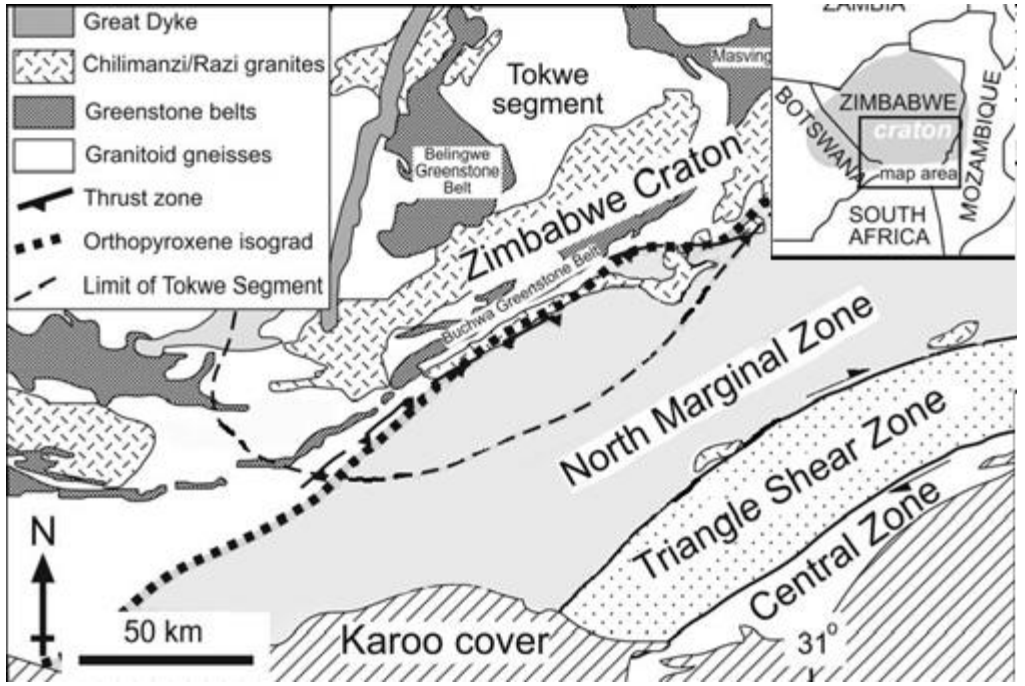


Other areas of interesting debate

How far north the deformation associated with the belt extends

The nature of the contact between the NMZ and the ZC

- Opx isograd marks the contact (*Worst 1962; Robertson 1973; Coward et al 1976*)
- The transition between the two terrains is gradual (*e.g. Robertson, 1973, 1974*).
- A thrust break marks the contact between the two terranes (*Worst 1962, Odell 1975, James 1975, Coward et al 1976; ; Mkweli et al 1995; Rollinson and Blenkinsop 1995; Mkweli and Blenkinsop 1997; Tsunogae et al 2001; Ranganai 2012; Tsunogae and Belyanin 2020*)



Lateral and vertical displacement along the dislocation zone?

Granulites

Some of the most interesting rocks associated with the LMB are granulites comprising charnockite-enderbite suites.

- Granulites are therefore a rare occurrence from which temperatures of the early Archaean crust can be directly estimated
- But are they the result of elevated P-T conditions from the mountain building processes and exhumation, or are of magmatic in origin (*Ridley and Kramers 1990; Ridley 1992; Blenkinsop 2011*)

Ultra-high temperatures

Temperatures between 900 and 950°C recorded in metamorphic mineral assemblages (*Tsunogae et al 2001*).

- The problem is how such temperatures were attained; whether by thickened crust, radiogenic heat or thermal plume.

Gneisses and migmatites

- These are rocks at the frontier between igneous and metamorphic rocks.

Gold mineralization

Gold mineralization in high grade terranes is rare compared to low-grade metamorphic granite-greenstone terranes (*Kisters et al 1998*)

- Tropicana gold deposit on the periphery of the Yilgarn craton in Western Australia mirrors the Renco Mine in Zimbabwe in that both deposits occur within 15 km of the edge of an Archaean craton in Archaean granulites (*Blenkinsop, 2013*) – Legacies of the Zimgarn?

Overlapping ages with adjacent cratons

Significance of Archaean ages of granulite facies metamorphism and magmatism in the LMB overlapping with greenstone belt ages and granitoid magmatism in the craton.

The 2 Ga LMB ages overlap with events in other terranes as demonstrated in the Magondi belt, Umkondo Basin, and the Bushveld Igneous Complex.

Conclusions

At 2.7 Ga the LMB is one of the largest high grade metamorphic belts of this antiquity in the world

The interpretation of features of the belt such as; age; deformation and metamorphism; the nature and the evolutionary history; relationships with adjacent terranes; metallogenesis, are still hotly debated

The Limpopo Belt is the most accessible, well exposed and extensively studied of the world's Archaean granulite-facies terranes, and provides a natural laboratory to investigate many questions about early earth processes

- areas of possible research are endless

- Indeed there are good grounds for designating the LMB a geoheritage terrane

THANK YOU