A review of the timing of gold mineralisation in the Zimbabwe Craton

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Photo credit: Brett Davis

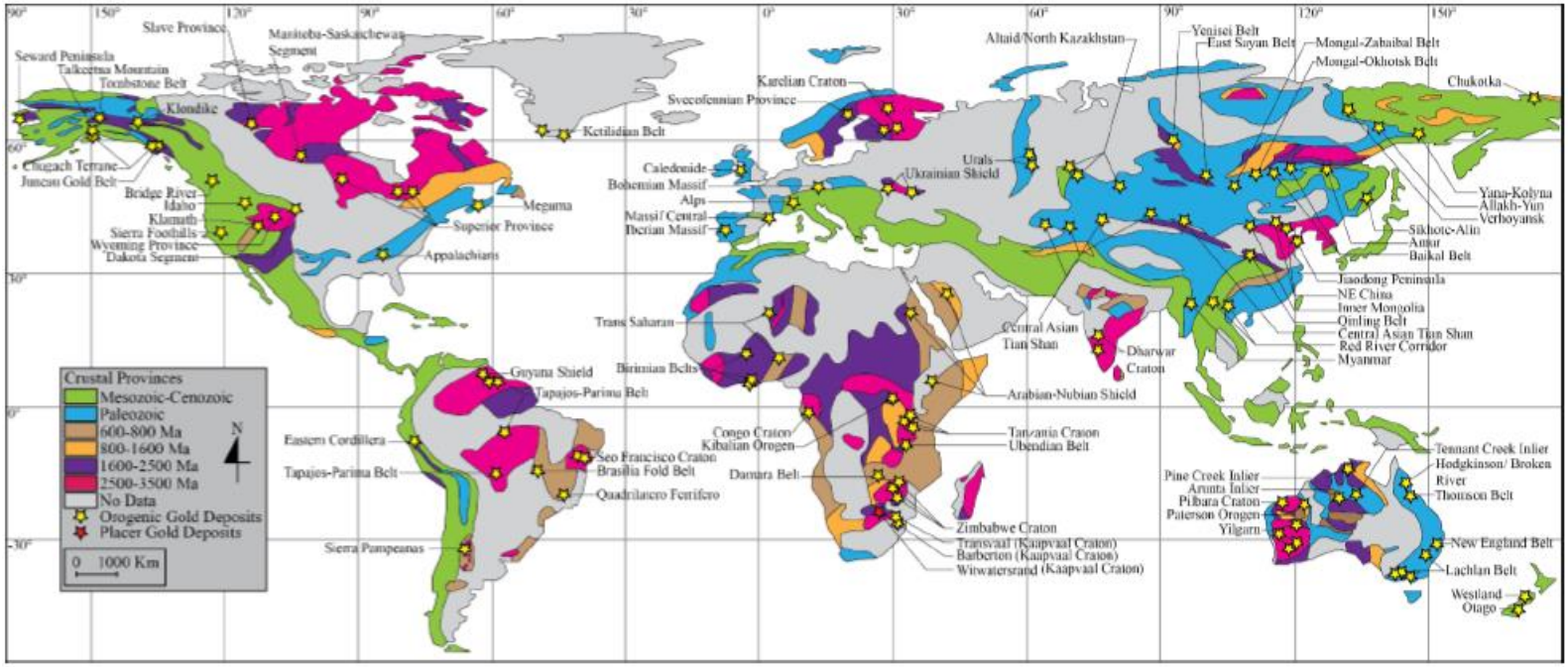
Outline of the talk

https://www.flickr.com/photos/47445767@N05/50930283628/

- Orogenic gold deposits in general
- How is the timing of gold mineralisation constrained?
- Why bother about the timing of mineralisation?
- Gold deposition episodes in the Zimbabwe Craton, with examples
- Contribution of craton-forming and modifying events to gold mineralisation

Orogenic gold deposits in general

- Vertically extensive, gold only & formed in broad thermal equilibrium with their host rocks, 2 - 20 km depth
- Hosted in Precambrian cratonic to Phanerozoic mobile belts
- Meteoric, magmatic hydrothermal and metamorphic models
- Source of mineralising fluids still controversial



Gloyn-Jones (2018) and references therein

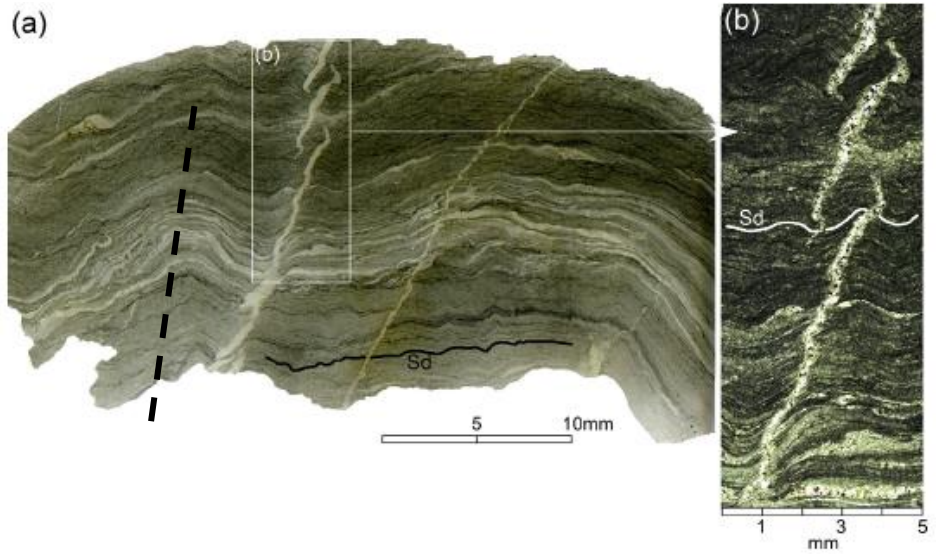
Groves et al. (2020) and references therein

Timing of gold mineralisation

Relative timing

- Use of overprinting and/or cross-cutting relations to determine the order of formation
- Timing and time gap between events not quantified
- Pre-, syn (early, late)- or post-deformational mineralisation
- Field relations are key!

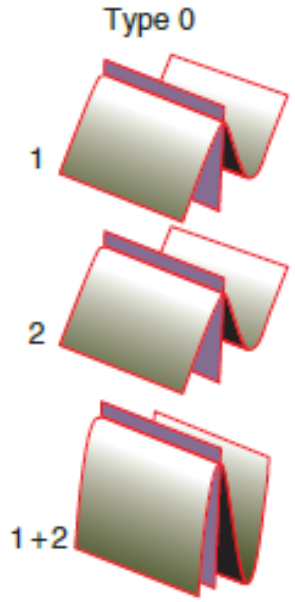
Phillips (2023)



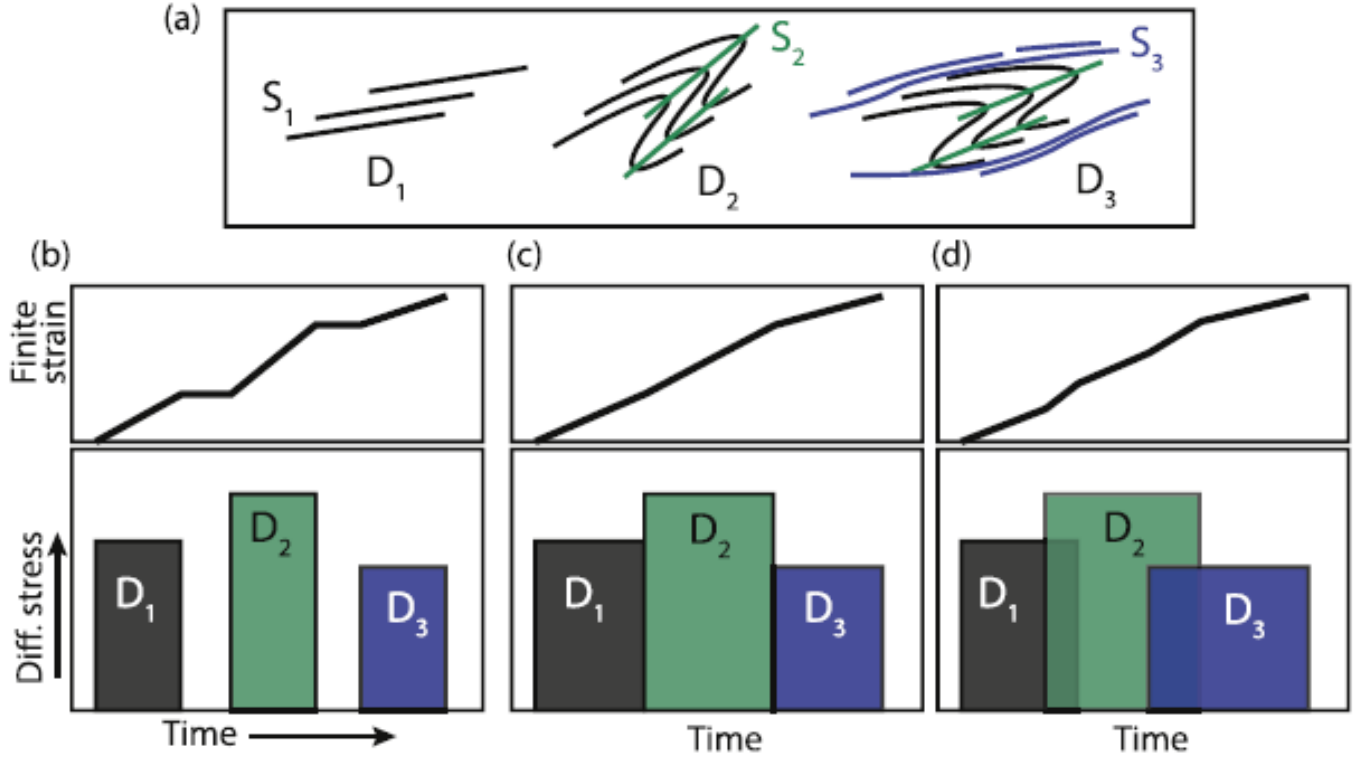
Druguet (2019)

Limitations of relative timing

- Relative timing of mineralisation is limited by:
    1. Complex and uncertain overprinting relations
    2. Prolonged deformation
    3. Polyphase vs progressive deformation
- This gap is covered by radiometric dating



Fossen (2010)

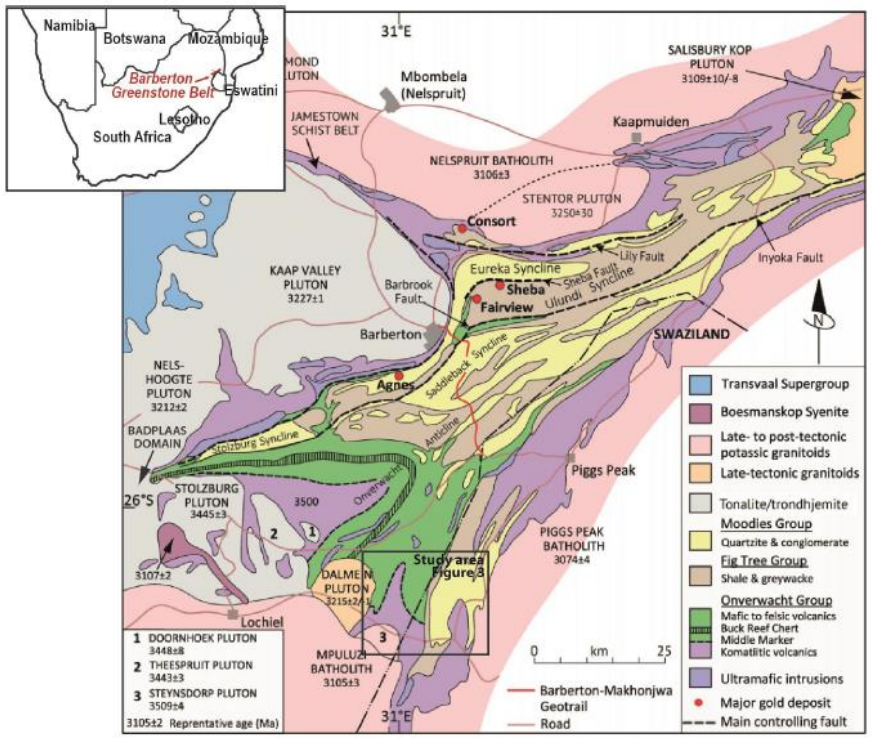


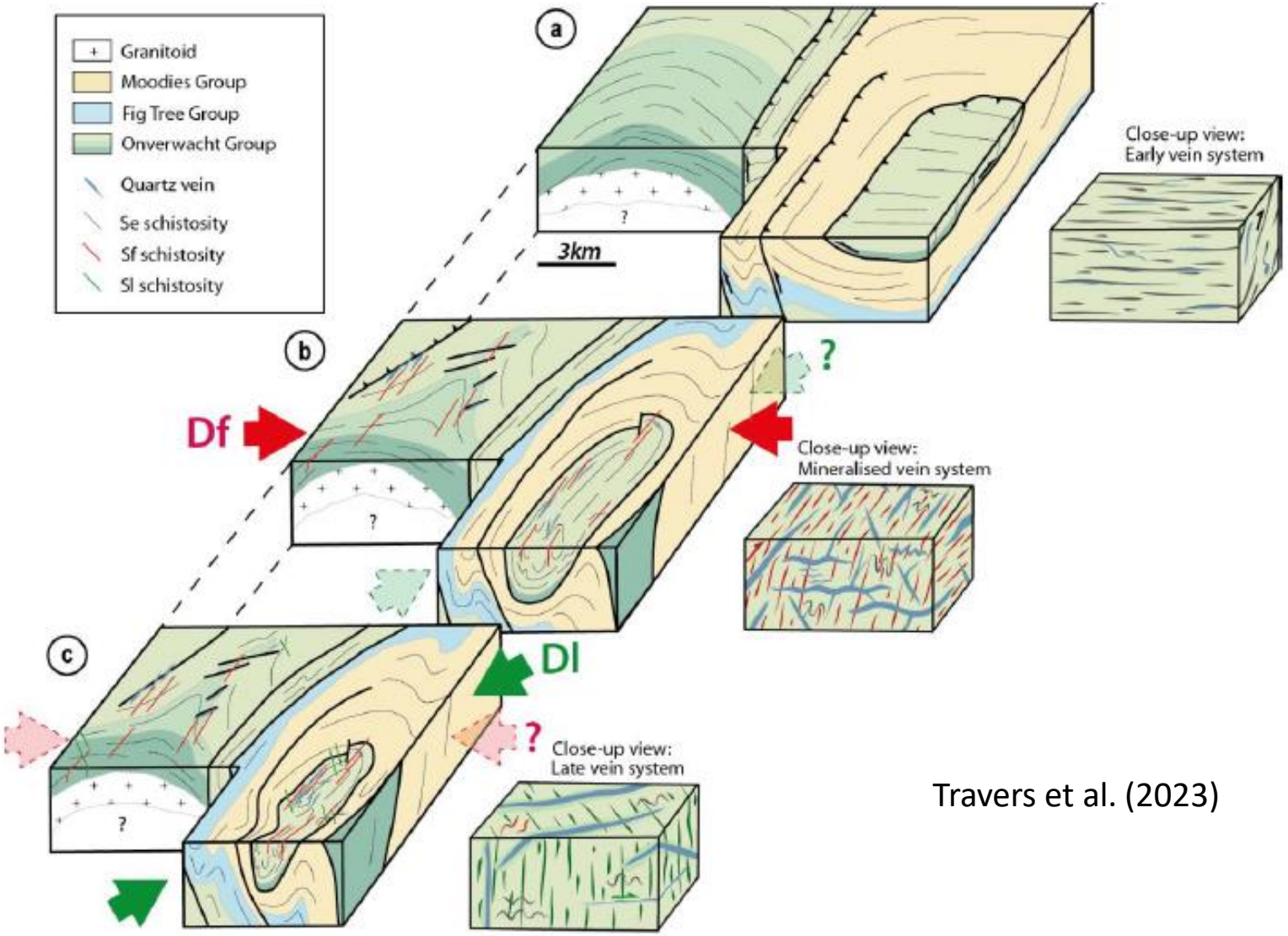
Fossen et al. (2018)

Relative Timing of gold mineralisation

Example – Southwestern Barberton greenstone belt

Gold mineralisation is syn-**F2** folding





Travers et al. (2023)

Timing of gold mineralisation

Absolute timing

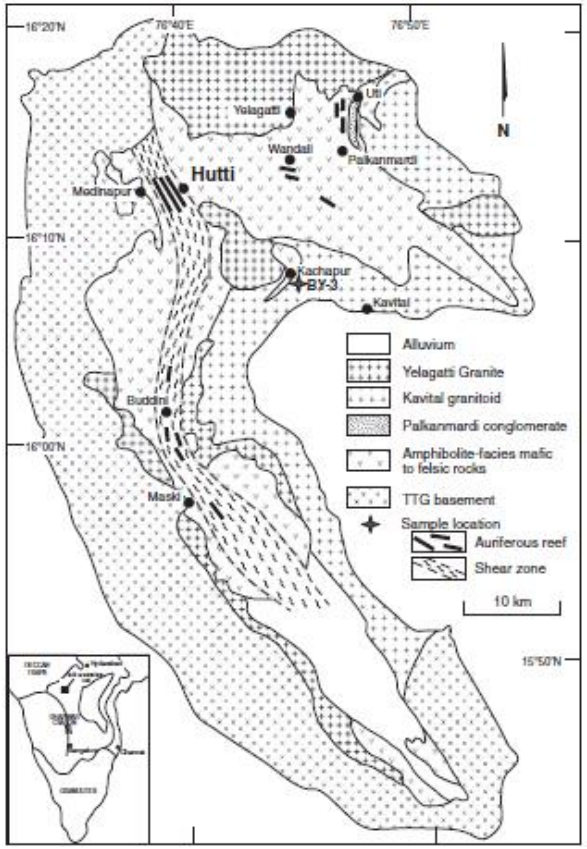
- Use of precise radiometric dates from datable minerals
- **Indirect** - dating minerals that form prior to or after mineralisation
- **Direct** - dating minerals with known intimate relationships with mineralisation e.g., hydrothermal zircon, monazite, xenotime
- **Limitations** – protracted events, uncertain field relations

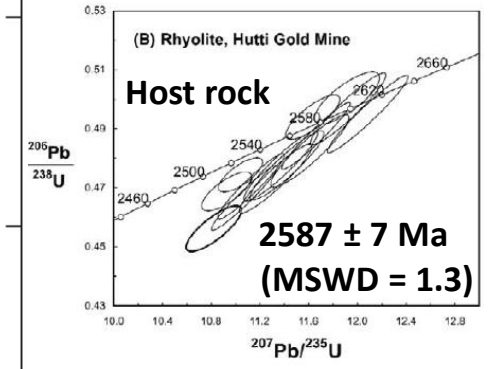
Lack of datable minerals unquestionably associated with gold mineralisation

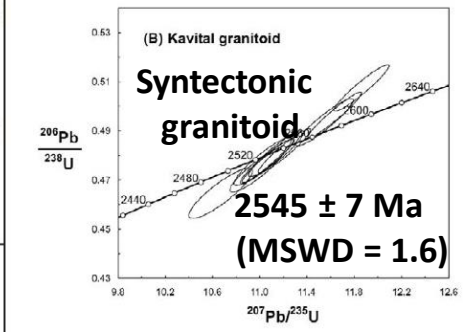
Field relations are key in constraining absolute timing!

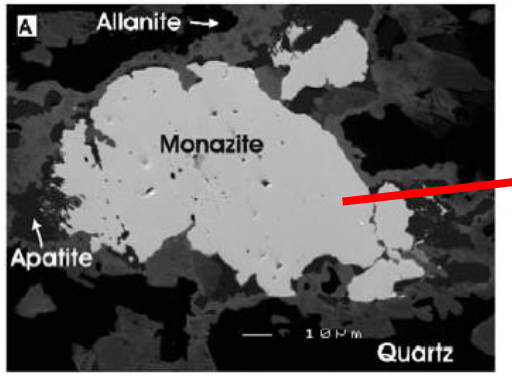
Phillips (2023), Sarma et al. (2008), Carpenter et al. (2005)

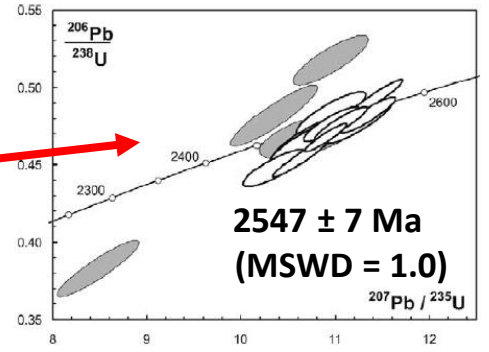
Example - Hutti gold deposit – eastern Dharwar Craton, India











Sarma et al. (2008)

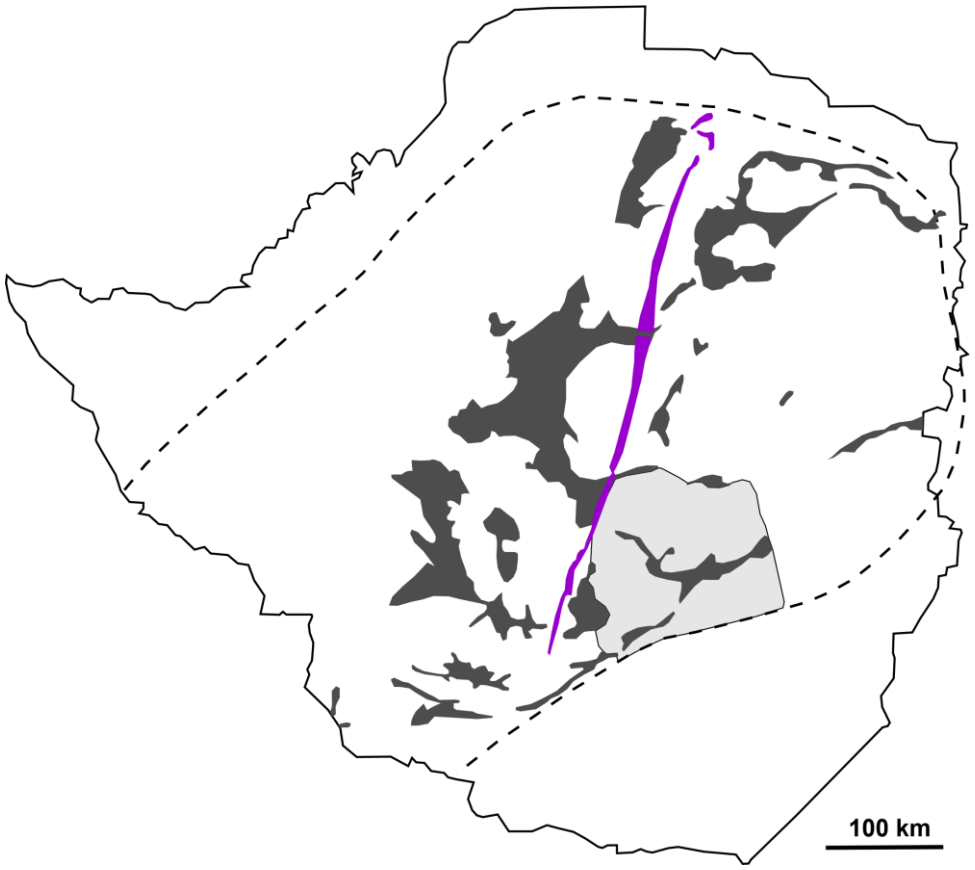
Why timing is important?

- Helps understanding gold mineralisation in its whole spectrum
- Relating the timing of gold deposition to sedimentation, magmatism and deformation is crucial in exploration of further deposits
- Crucial in target generation

The case of the temporal and genetic linkage of LCT pegmatites to ~ 2.6 Ga Chilimanzi Suite of granites in Zimbabwe

Can we link gold deposition episodes to craton-forming and modifying events in Zimbabwe?

Craton forming events - Zimbabwe



Modified after Prendergast and Wingate (2007)

		Age	Intrusion
Shamvaian metasediments		~ 2.66-2.57 Ga	Chilimanzi Suite: ~ 2.6 Ga Bindura Stock: ~ 2.6 Ga Mazowe Stock: ~ 2.6 Ga
Bulawayan Supergroup – Upper Greenstones – Western Succession	Passaford Fm Avalon Fm Surprise Fm Maparu Fm Maliyami Fm Iron Mask Fm	~ 2.68-2.75 Ga	Sesombi Tonalite: ~ 2.67 Ga Wedza Suite: 2.7 Ga Mashaba-Chibi dykes: ~ 2.7 Ga Mutare Tonalite: ~ 2.7 Ga
Bulawayan Supergroup – Upper Greenstones – Eastern Succession	Cheshire Fm Zeederbergs Fm Reliance Fm Manjeri Fm		
Bulawayan Supergroup – Lower Greenstones – Eastern Succession	Koodvale Fm Arizona Fm Eldorado Fm Brooklands Fm Redcliff Jasp. Fm Hokonui Fm Manica Felsic Fm Buchwa Quartzite Bvute	~ 2.8-3.0 Ga	Somabula Tonalite: ~ 2.75 Gwenoro Dam gneiss: ~ 2.77 Ga Chingezi Suite: ~ 2.85 Ga Gnezi Tonalite: ~ 2.88 Ga Rhodesdale Gneiss: ~ 2.95
Sebakwe Proto-Craton	Shabani Gneiss Tokwe Gneiss	Pre-3.2 Ga	Mont d'Or Granite: ~ 3.35 Ga Mushandike Granite: ~ 3.34 Ga

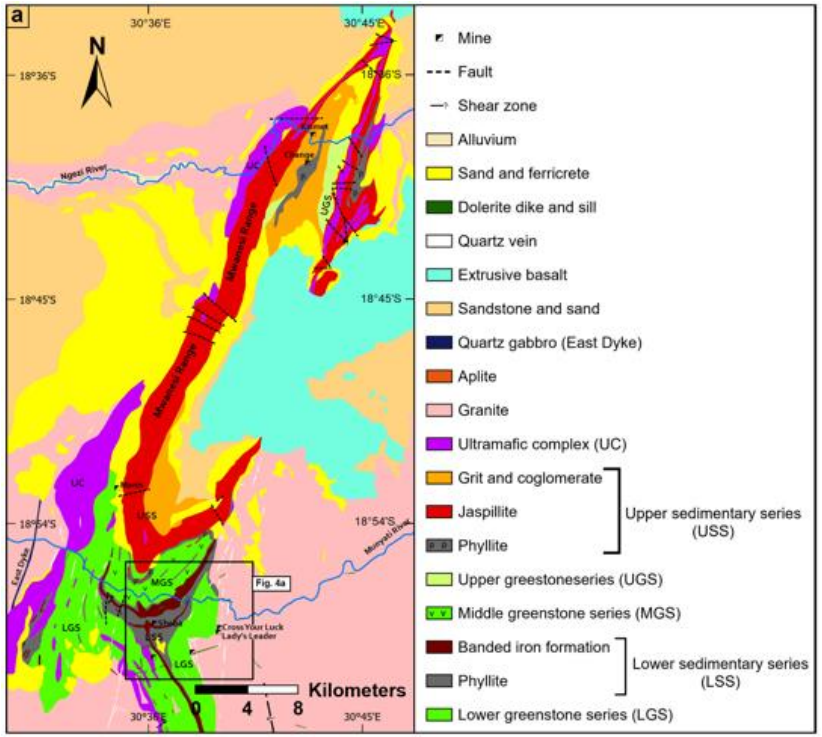
Modified after Jelsma et al. (2021)

Craton modifying events

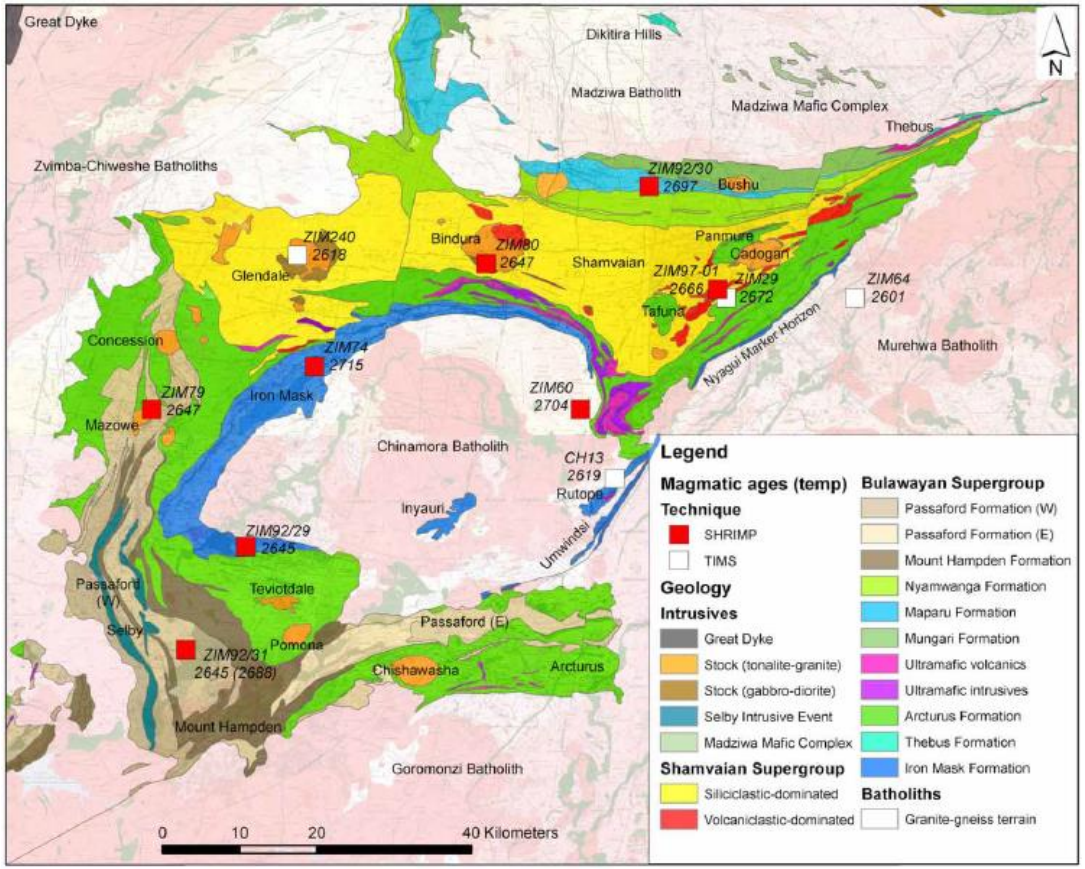
2.69-2.62 Ga deformation event

- Well constrained in the Bindura-Shamva,

  Mwanesi & Midlands greenstone belts

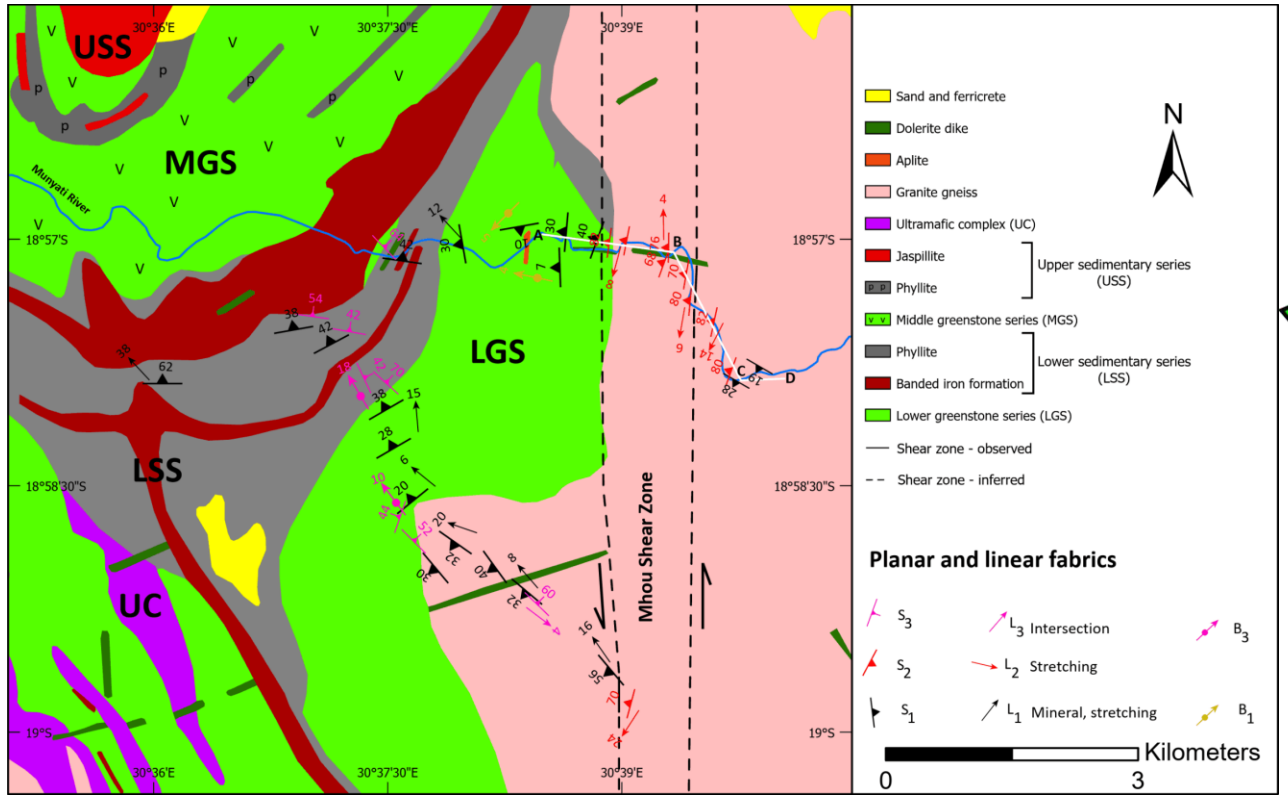


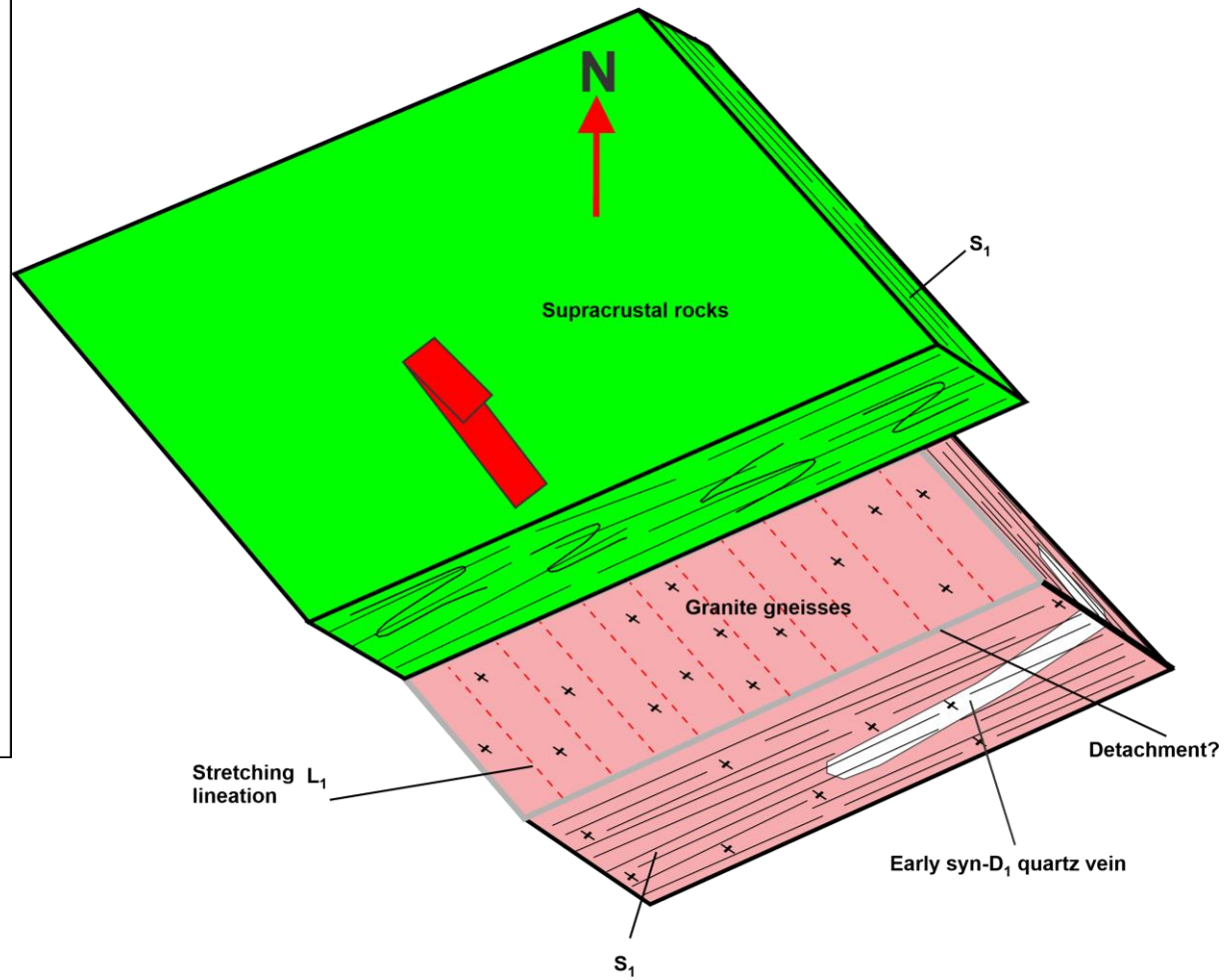
Modified after Worst (1962)



Jelsma et al. (2021) and references therein

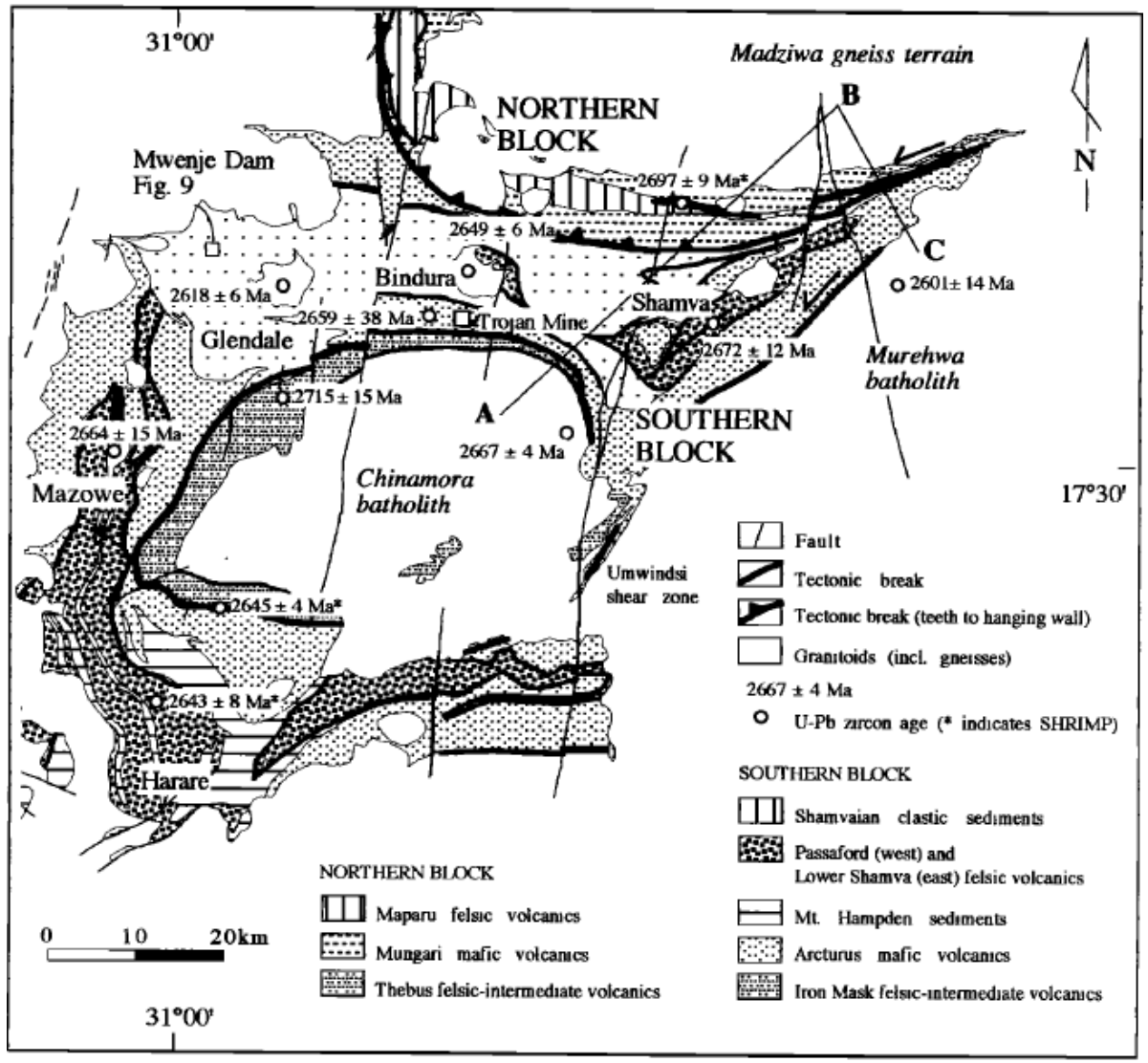
2.6 Ga deformation – Mwanesi Greenstone Belt

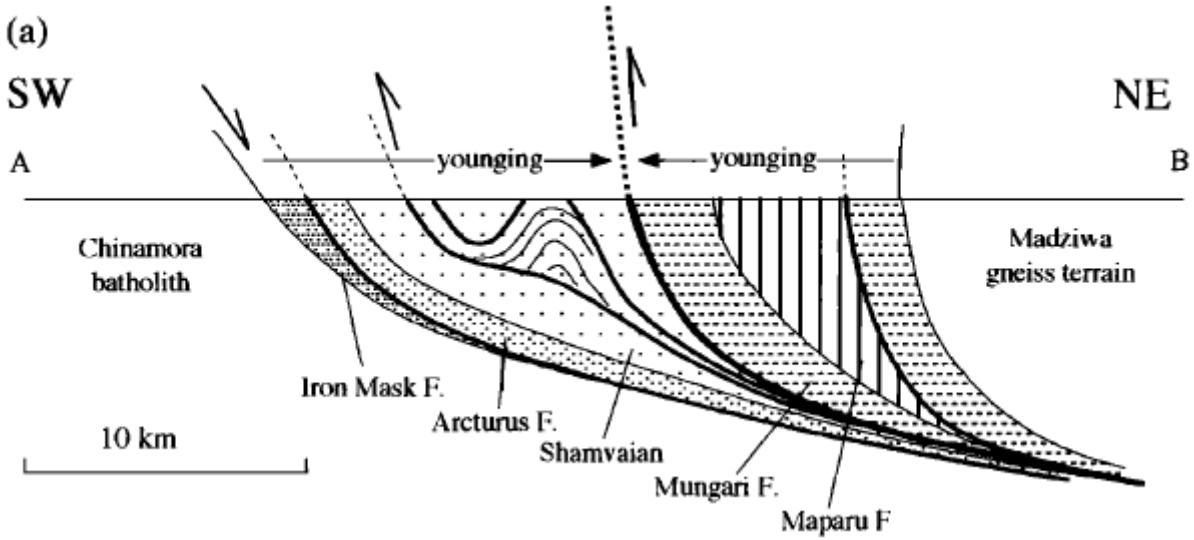




Mapingere et al. in prep.

2.6 Ga deformation – Bindura-Shamva



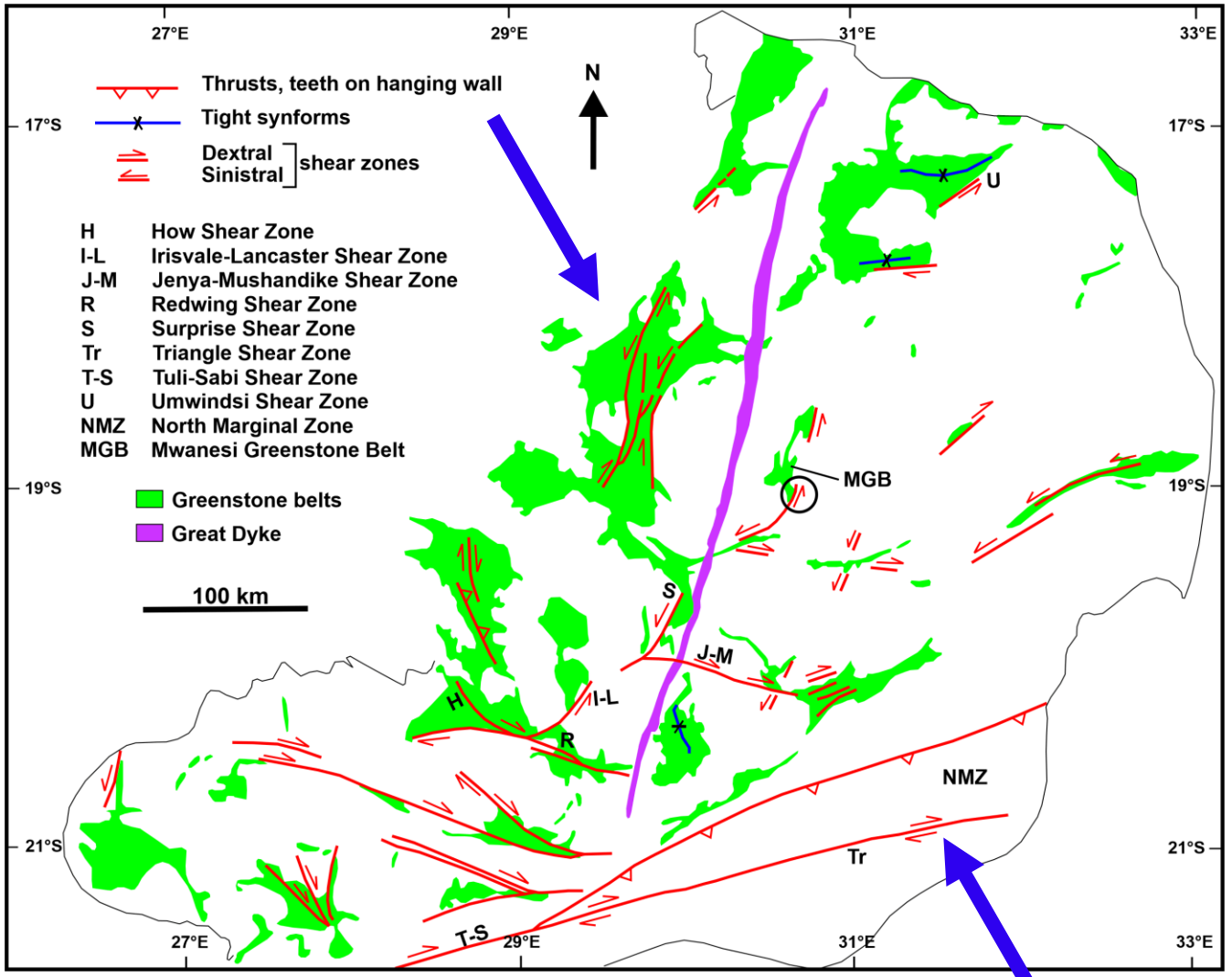


Jelsma and Dirks (2000)

Craton modifying events - Zimbabwe

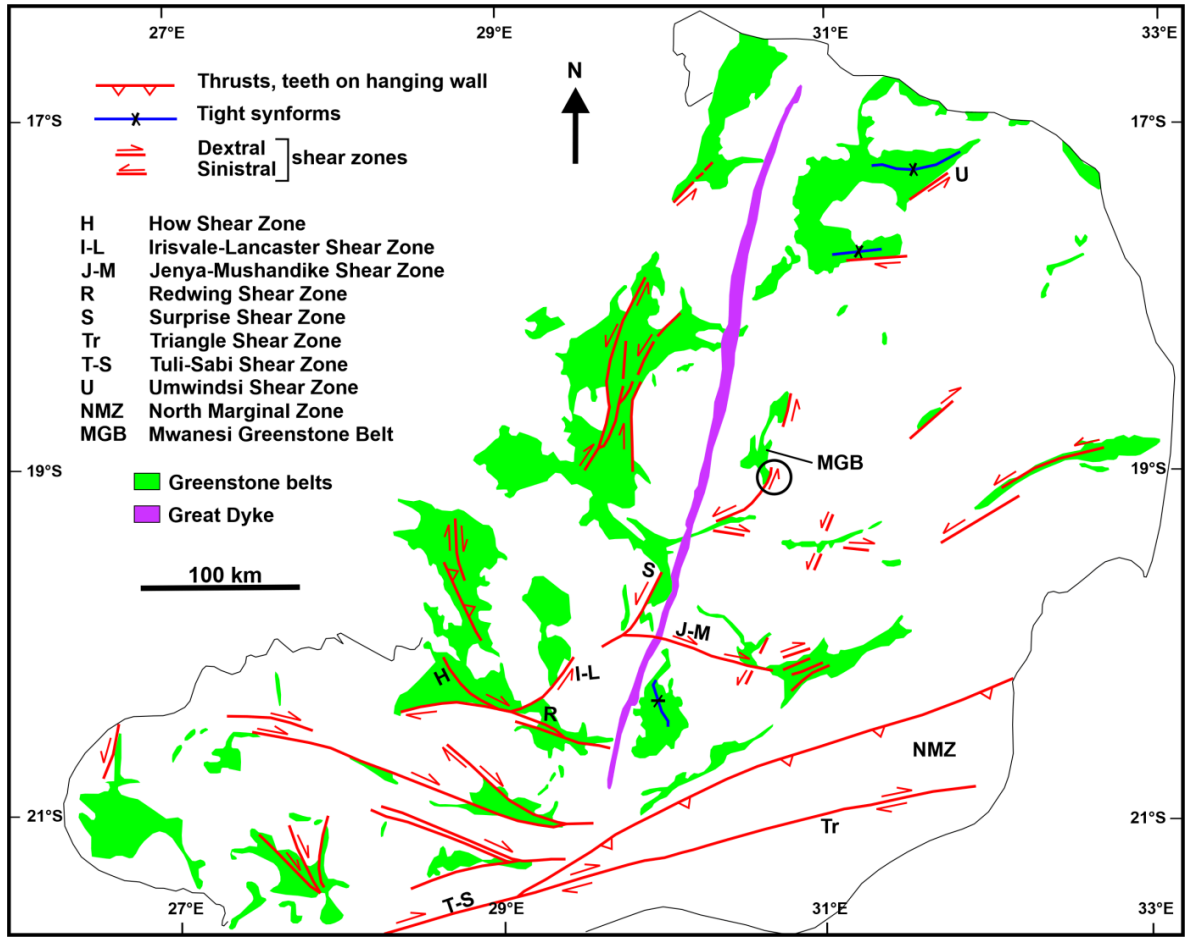
2.58 Ga deformation event

- Temporally related to thrusting in the NMZ of the Limpopo belt
- NW-SE-directed shortening

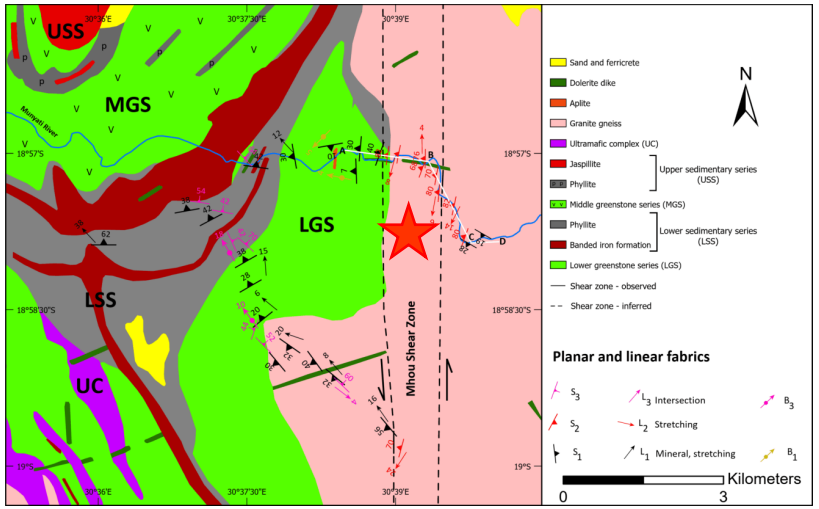


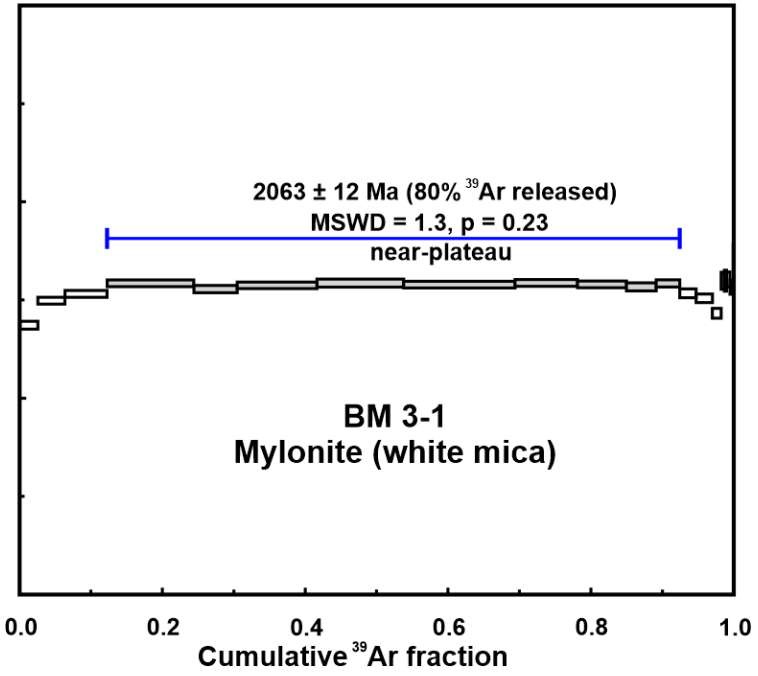
Modified after Treloar and Blenkinsop (1995)

Reactivation of 2.58 Ga shear zones at 2.0 Ga



Modified after Treloar and Blenkinsop (1995)

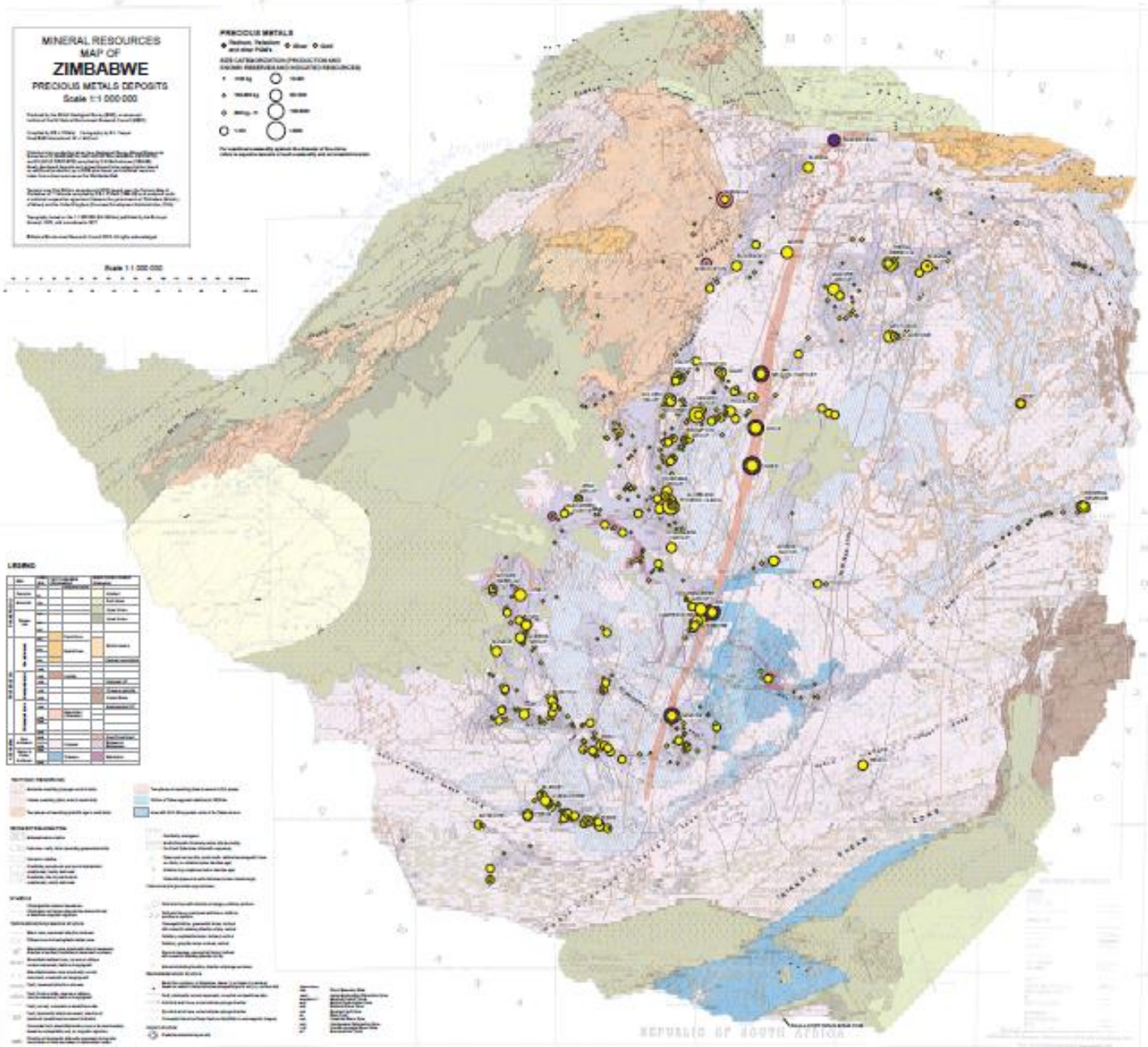




Mapingere et al. in prep.

- Constrained in the Triangle Shear Zone (CZM)

Gold mineralization in the Zimbabwe Craton

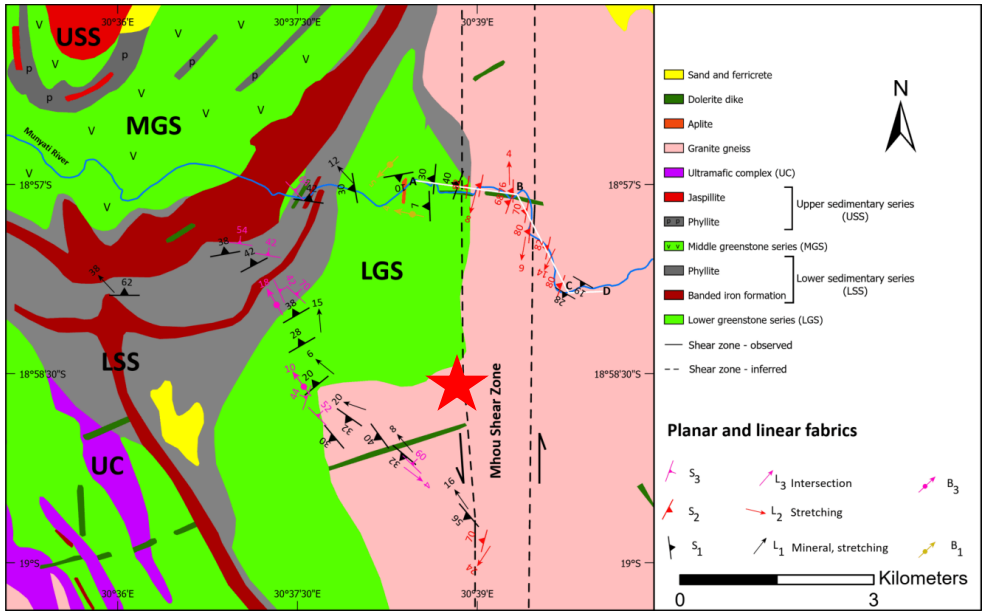


- Hosted in Archaean greenstone belts and surrounding granites
- Show strong structural control

Major gold forming events in Zimbabwe

- Three major gold deposition events:
- 2.68-2.62 Ga
- 2.58 Ga
- 2.0?

2685-2631 Ma – Mwanesi greenstone belt



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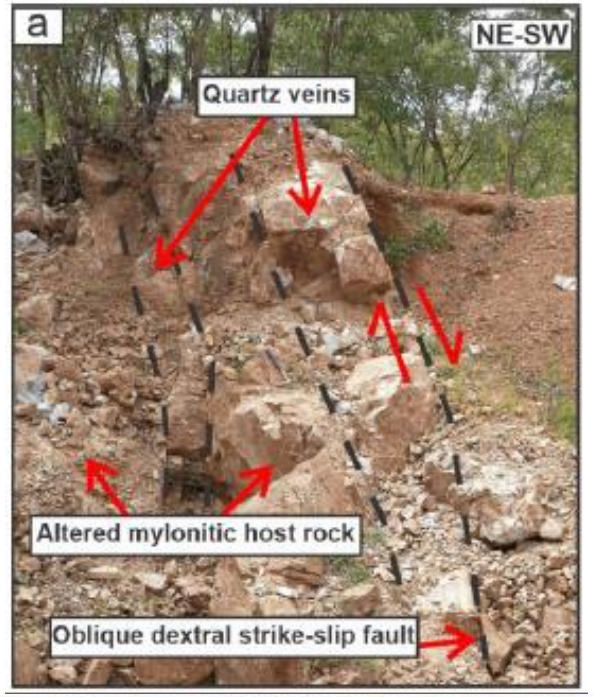
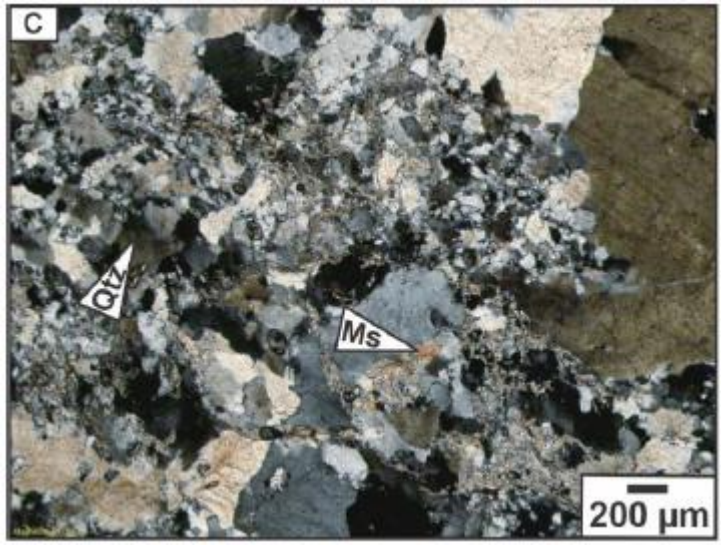
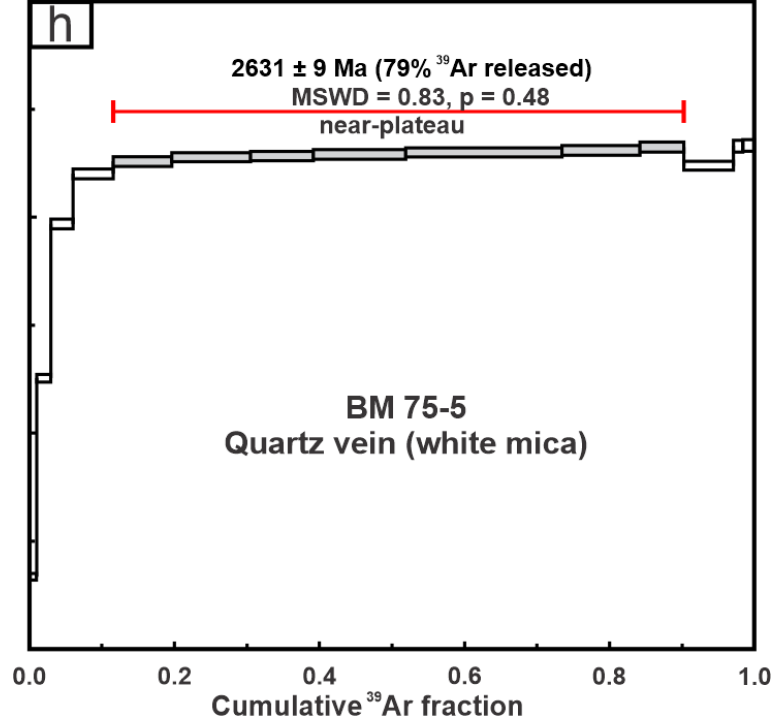
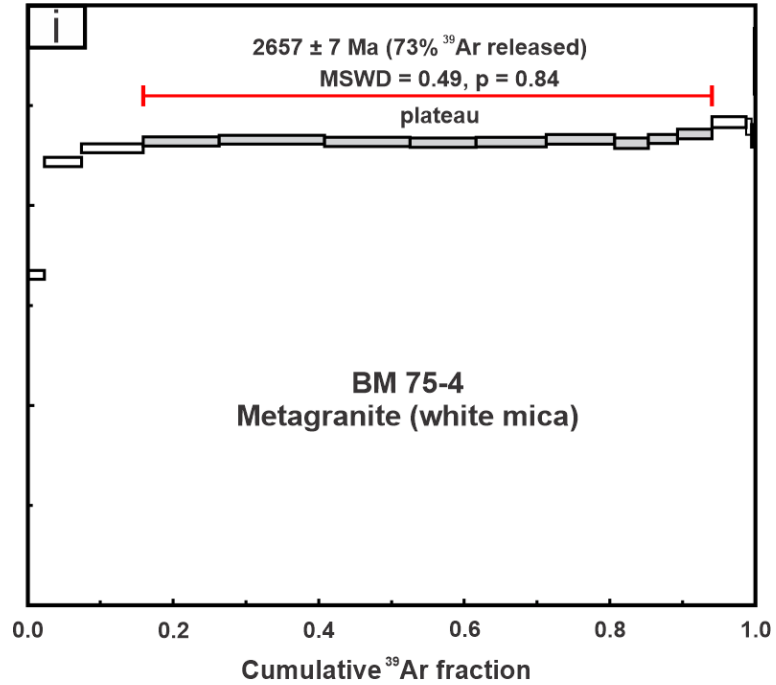


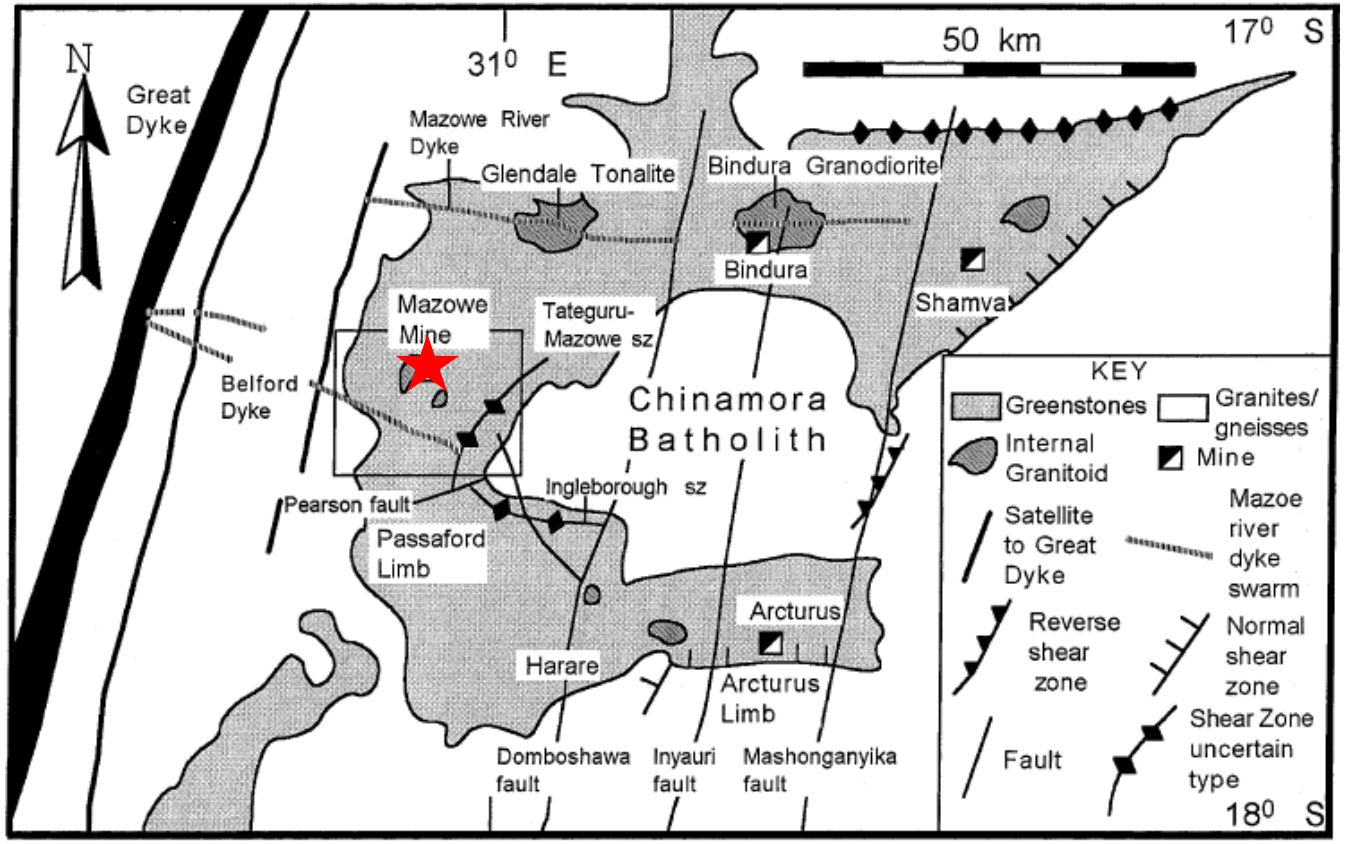






Major gold forming events in Zimbabwe

~ 2.6 Ga gold deposition in the Mazowe

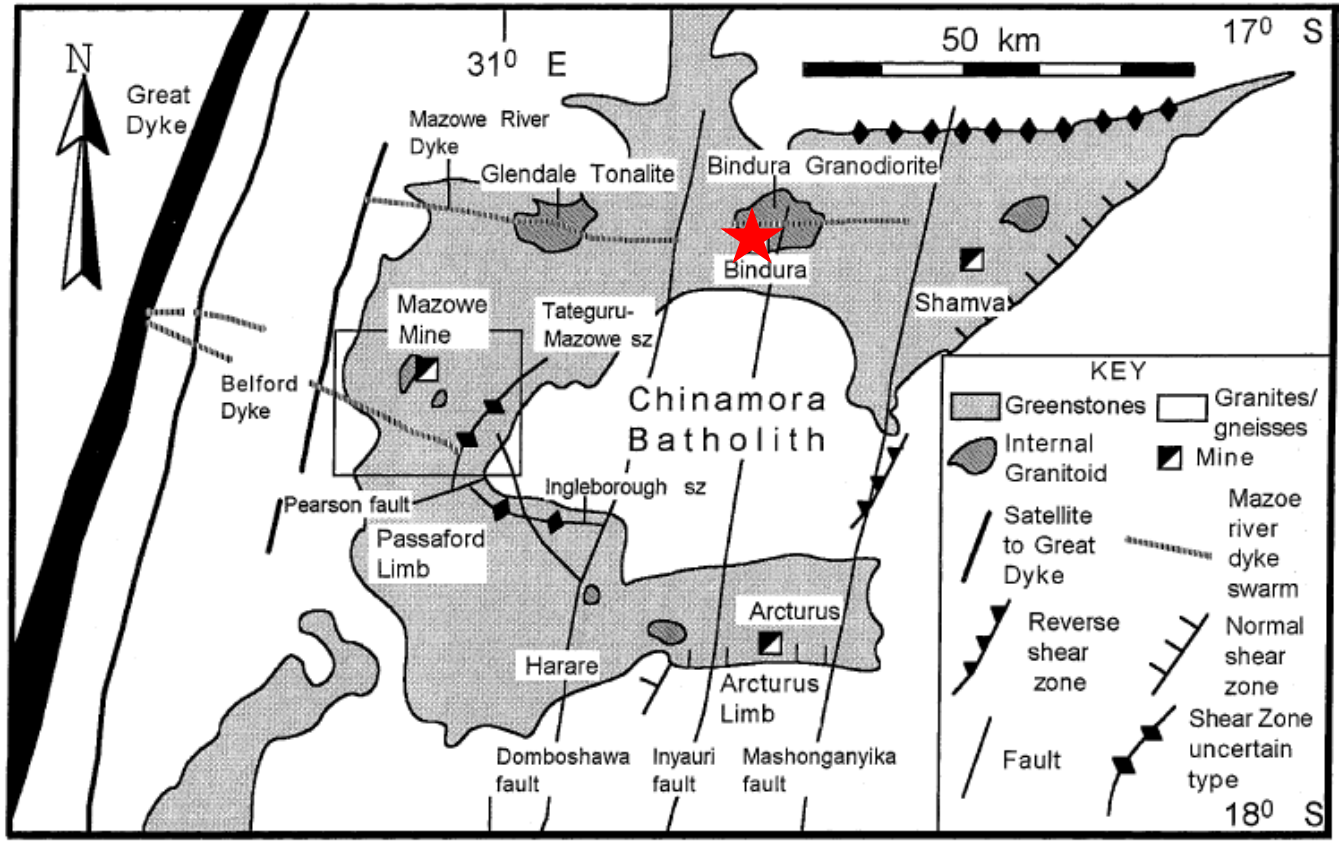


- Mineralisation controlled by reverse (E-W) and strike-slip shear zones (WNW- & NE-striking, D2)
- D2 temporally related to late 2.6 Ga Chilimanzi emplacement
- Timing constrained from field relations

Blenkinsop et al. (2000)

Major gold forming events in Zimbabwe

~ 2.6 Ga gold deposition in the Bindura

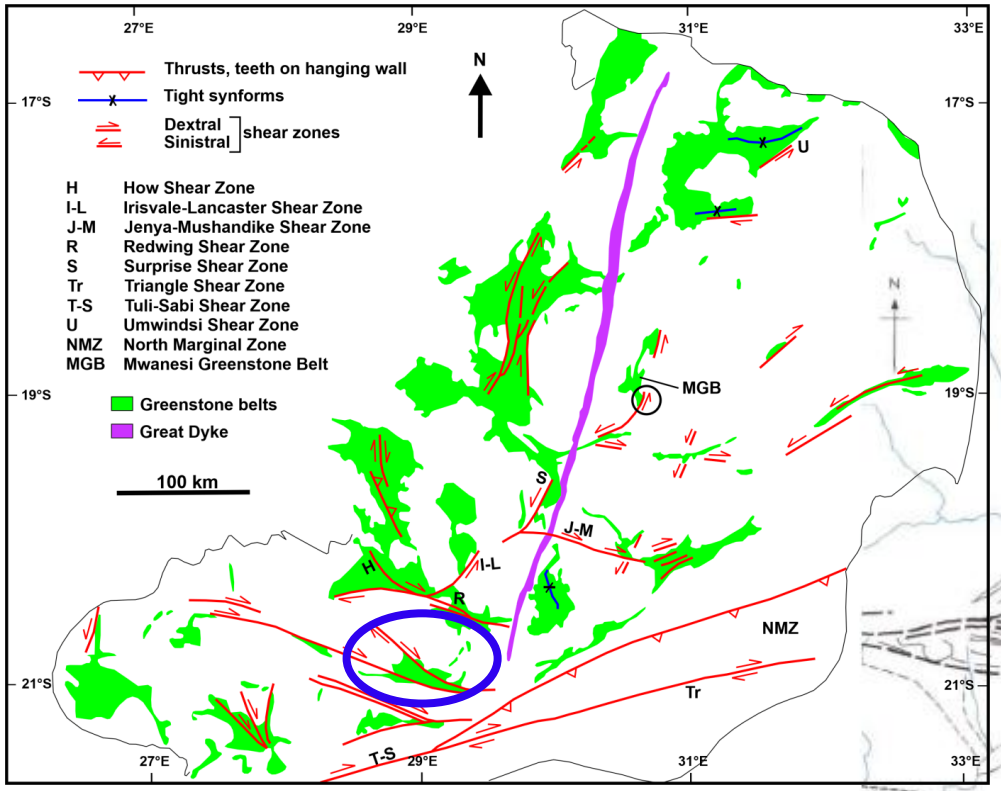


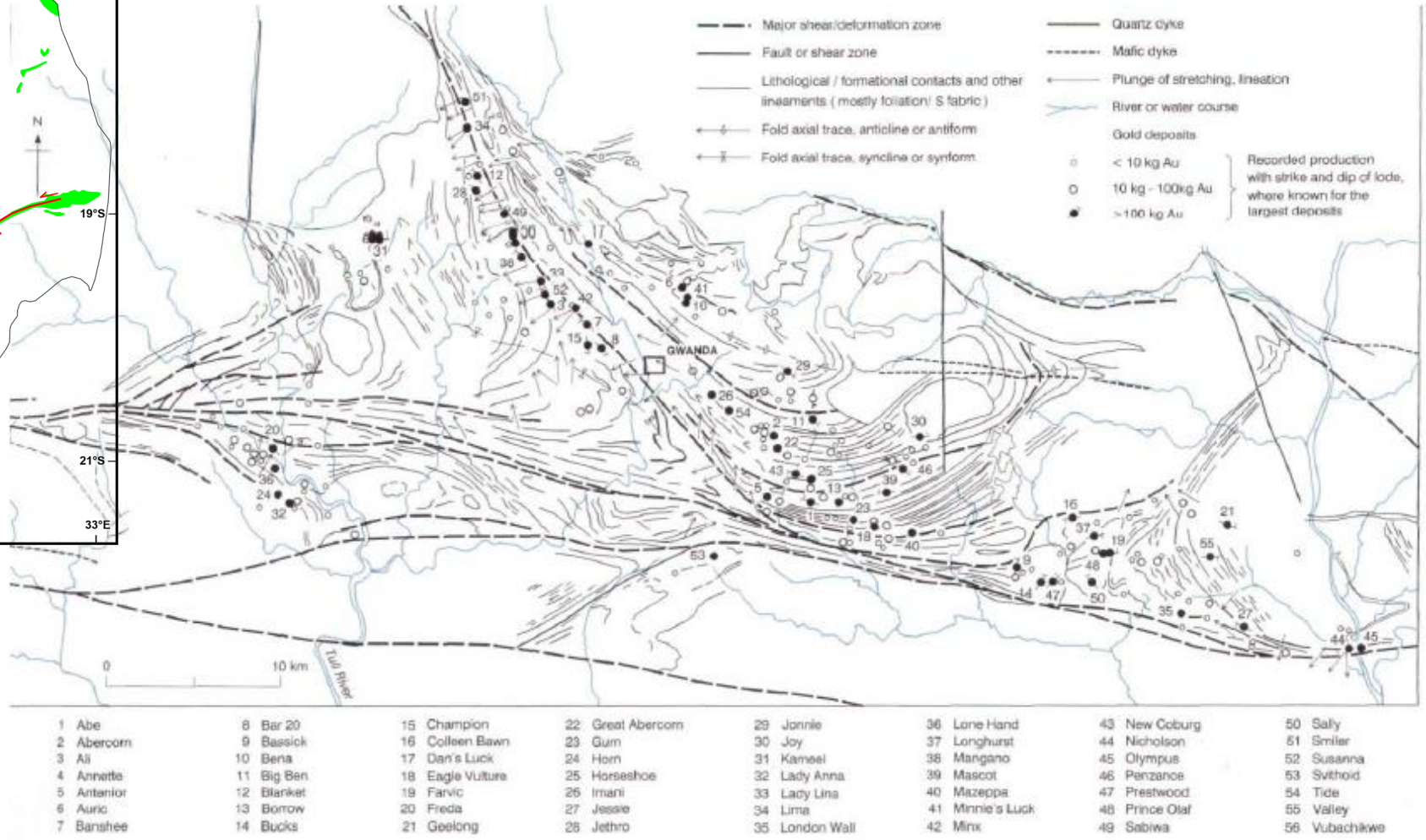
Blenkinsop et al. (2000) and references therein

- Shear zone hosted gold in a granodiorite
- Timing constrained from field relations
- Gold deposition synchronous with the late to post-tectonic granitoids
- Timing still controversial

Klemm and Krautner (1999)

2.58 Ga event – Gwanda greenstone belt



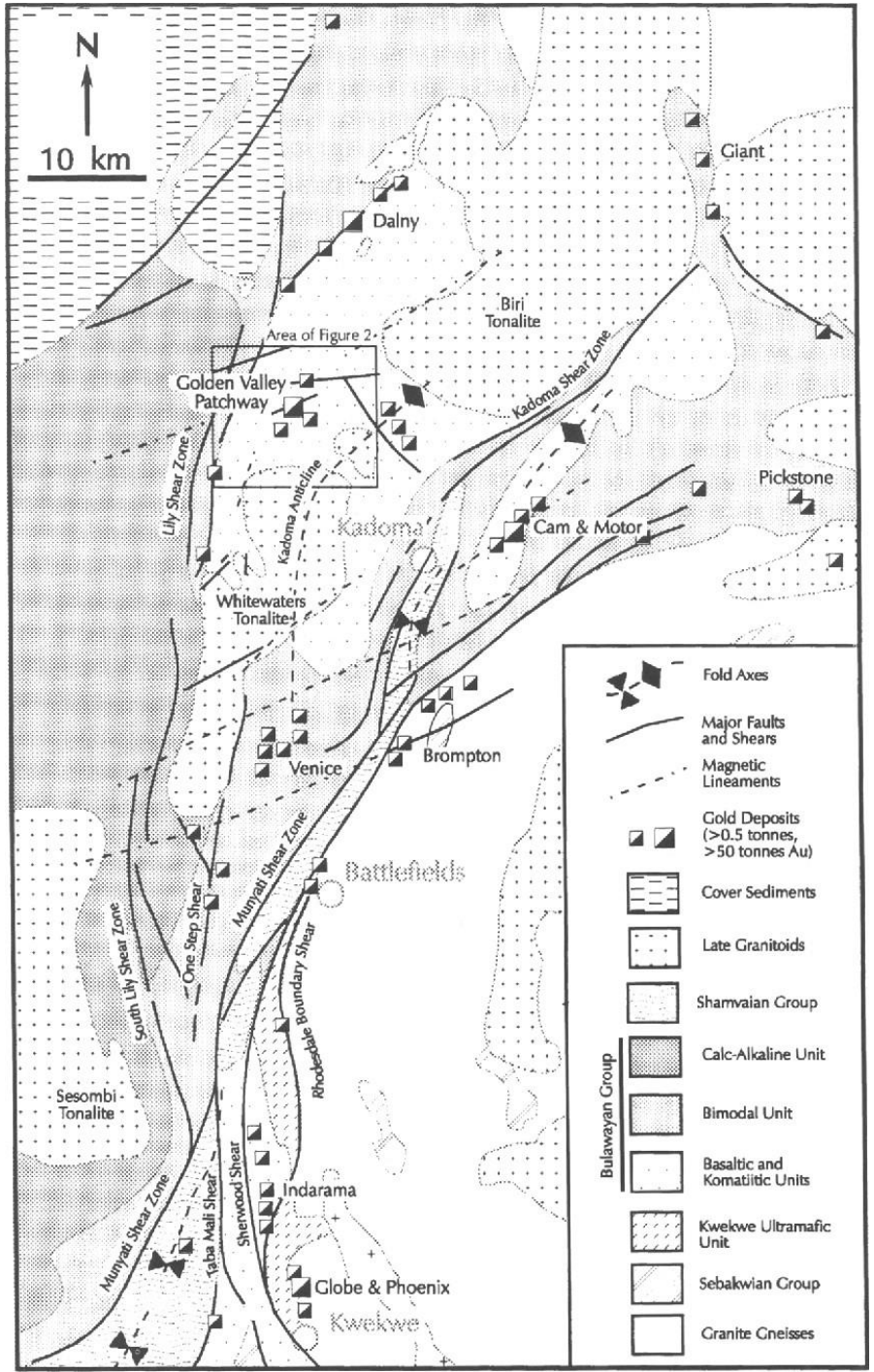


- Gold deposition related to the 2.58 Ga thrusting in the NMZ?
- Based on kinematics

Landsat TM image interpretation (Campbell and Pitfield, 1994)

2.0 Ga overprinting event

- Late Proterozoic reactivation of Midlands greenstone belt shears zones
- Overprinting of the earlier formed 2.58 Ga gold deposits?



Herrington (1995)

Take home messages

- Three major gold deposition episodes are recorded in the Zimbabwe Craton i.e., 2.68-2.62 and 2.58 Ga.
- Gold deposition episodes were broadly synchronous with late Archaean deformation of the craton and emplacement of the Chilimanzi Suite.
- Evidence of late Proterozoic overprinting is common especially in gold deposits formed at 2.58 Ga.
- More precise dates of gold mineralisation remain in the craton are important.

Key unresolved questions

- The 2.6 Ga deformation event is poorly characterised, only covered in a few greenstone belts. Was this event recorded in all the greenstone belts?
- How was the 2.6 Ga deformation event related to gold mineralisation?
- How far did the 2.6 Ga Chilimanzi Suite of granites contribute towards gold the ~ 2.6-2.58 Ga gold deposition episodes?
- Thrusting in the NMZ is poorly constrained (affected the Razi and not the Great Dyke) yet the formation of many shear zones is inferred to be temporally related to this event.

Acknowledgements

IRP BuCoMO

Building Continents - From Mantle to Ore

Thank you

CARDIFF UNIVERSITY
PRIFYSGOL CAERDYDD

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