On the spatial association of granite intrusions & gold mineralization in the Belingwe greenstone belt, Zimbabwe

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Talk format

1. Introduction
2. Current understanding on the role of granitoids in gold mineralization- a brief synthesis
3. Regional geology overview of the Belingwe belt & environs
4. Field observations
5. Discussion- explore significance of granite intrusions with respect to Au mineralization.
6. Implications to exploration
7. Conclusions

Introduction

- Belingwe greenstone belt: popular & world-class belt, well-preserved greenstone stratigraphy (Beligwean, Bulawayan, Shamvaian Supergroups).
- Constitutes type-area from which models on greenstone belt development & evolution (Kusky, 1998; Hunter et al. 1998; Hofmann & Kusky, 2004, Shumizu et al. 2005; Sawada et al. 2015; Orpen & Martin, 2017).
- Has attracted geological, geochronological & geochemical investigations.
- Mugumbate (2017): reckons that that the "Economic aspects" of the belt have been largely neglected apart from asbestos mining in ultramafic sills. Main reason of neglect: small size of Au deposits (narrow < 1.0 m widths).
- However, economic aspects partly dealt with in Bulletin 43- Worst (1957), Bulletin 12 -Keep (1929), Bulletin 83- Martin (1978), Mhindu (1998) and Campbell & Pitfield (1994).
- Mugumbate (Short report No. 51) gave a recent synthesis of the regional distribution and controls of Au mineralization in the belt.
- Most mines operated by small-scale miners. Small scale miners contribute >60 % of Zimbabwe gold production!!

Current understanding on the role of granitoids in gold mineralization- a brief synthesis

1. **Metamorphic secretion**: granitic intrusion may provide heat source that leach the gold out of greenstones & sediments which trigger hydrothermal fluid flow along shear zones (Saalmann et al. 2010).

2. Skarn deposits: are typically formed at the contact of granite intrusions & carbonate rocks (Sial et al. 2011).

3. Granite pluton hosted quartz veins: auriferous quartz veins hosted by syn-tectonic quartz diorites to gabbros (Saalmann et al. 2010). Freda Rebecca and Aryshire mines in northern & NW Zim are hosted in sheared granodiorites.

4. Tectonic effects: quartz veins peripheral to granite plutons: Midlands Greenstone belt (Campbell & Pitfield, 1994).

Article: The gold content of some Archaean rocks and their possible relationship to epigenetic gold-quartz vein deposits (Meyer & Saager, 1985)

Kaapvaal and the Rhodesian cratons geochemical investigation:

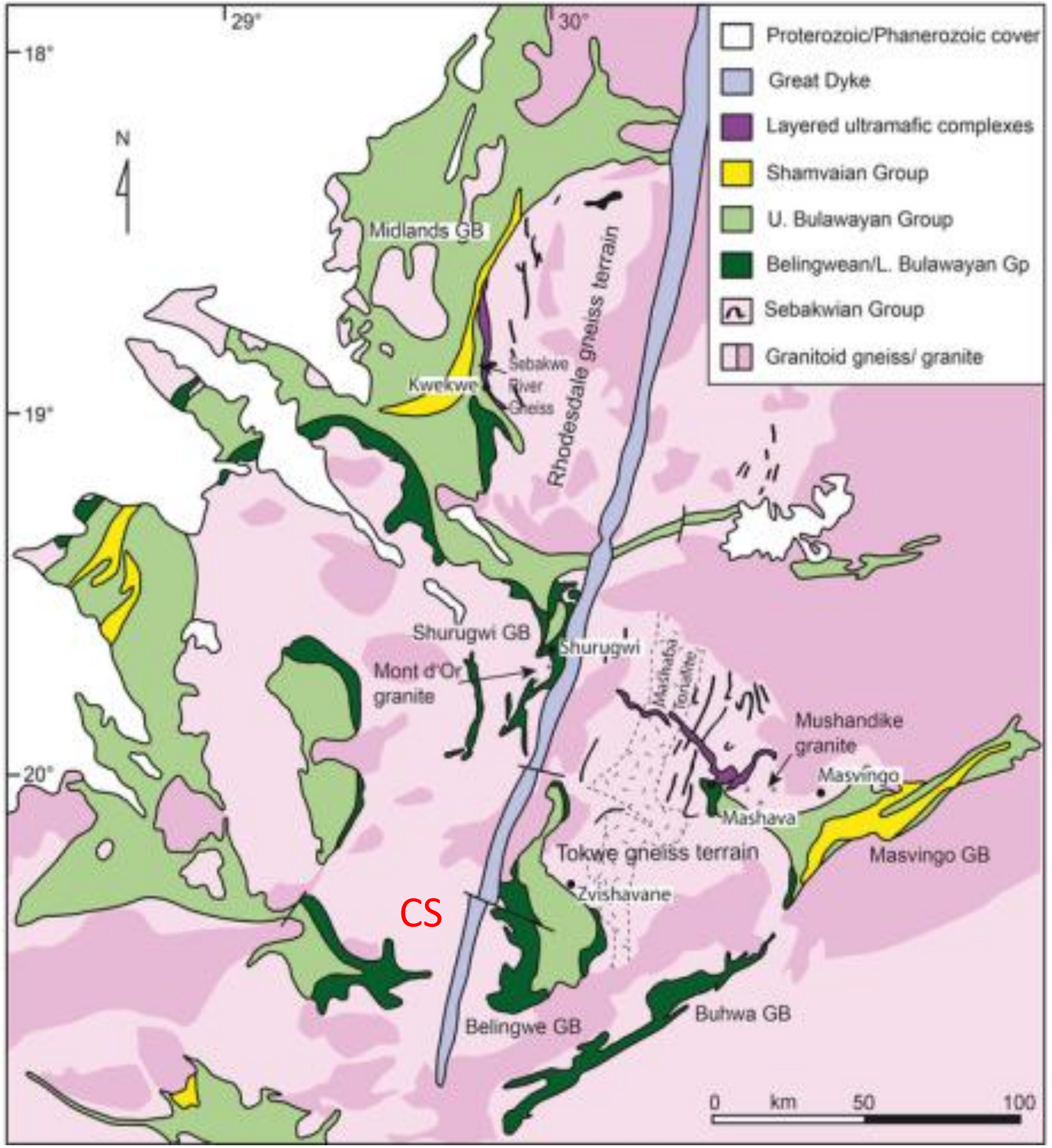
- volcanic rocks (komatiitic and tholeiitic): 0.1–372 ppb Au
- granitic rocks of the basement: 0.3–7.8 ppb Au
- iron-rich chemical sediments: 1.0–667 ppb Au

Volcanic rocks & Fe-rich chemical sediments are favorable sources for epigenetic gold mineralization formed by metamorphic secretion.

Granitic rocks are less suitable primary gold sources.

Finding explains the close spatial relationship which is common between gold-quartz veins & greenstone belts.

Geological overview: geology map of south-central Zimbabwe craton



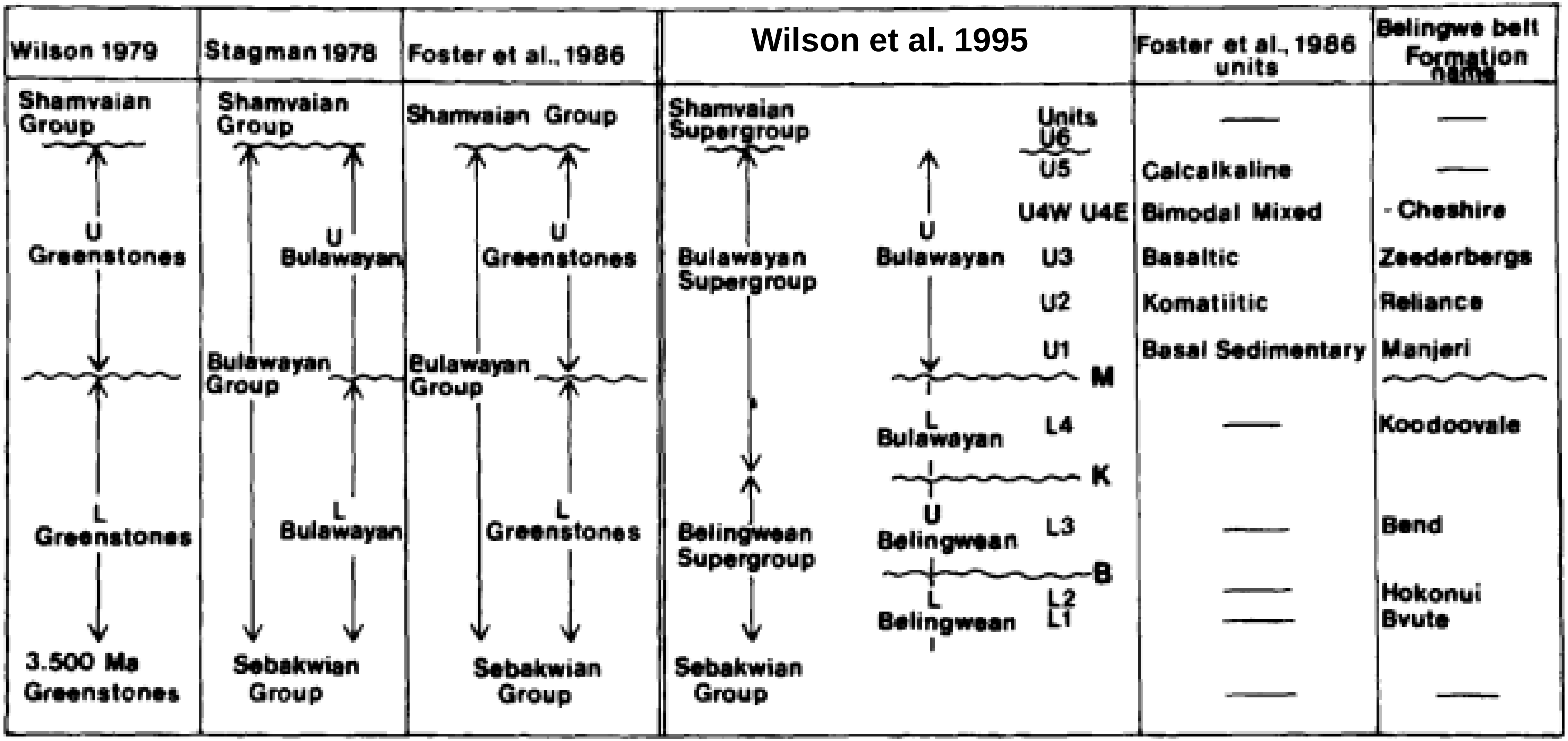
(from Hofmann & Chagondah, 2018)

Western part: Chingezi Suite (CS): 290-2.80 Ga

Eastern part: Shabani Gneiss: 3.5 Ga

Zimbabwe greenstone stratigraphic nomenclature

(from Wilson et al. 1995)



Belingwean or Lower Greenstones…bit of house keeping?

Hokonoui Formation (HF), L2: zircon U-Pb; c. 2904±9 Ma, Wilson et al. 1995): comprise mainly felsic volcaniclastic rocks, mafic greenstones (doleritic) & minor BIFs (Orpen & Martin, 2017).

In the Belingwe area: the Lower Bulawayan (L4- Koodovale Formation: zircon U-Pb; c. 2831±6 Ma: Wilson et al. 1995) is envisaged to be an incomplete cycle of greenstone development as it is devoid of mafic magmatism (Wilson et al. 1995).

- HF: felsic (porphyritic- feldspar phenocrysts) & mafic (subordinate) greenstones occur as alternating sequences with a regional N-S strike.
- The lithological contacts across the greenstone sequences are sheared.
- Shearing was enhanced by competence contrasts between different rock types.

Deformation evidence in the Belingwe belt & environs

- Tight folding of the Bvute and Hokonui Formations (Orpen & Martin, 2017).
- Shear zones: large carbonated shear zone (SZ), found along the base of the Vanguard Ultramafic Sill.
- The SZ cross-cuts the felsic rocks and the contact between the Hokonui-Bvute Formations to the west (Orpen & Martin, 2017).
- Rock units W & S of Mberengwa belt have suffered a greater intensity of deformation (Orpen & Martin, 2017).
- This is evident in the development of a strong pervasive cleavage in outcrops.
- Sheared quartz-sericite schists notable across western part of the belt.
- The Chingezi gneisses: foliated or banded, tightly folded in places.

Felsic plutonic record in the environs of the Belingwe belt

- ❖Granite magmatism exploits structural weaknesses in the continental crust such as shear zones & faults.

- ❖Belingwe belt: record is documented by multiple pulses of Chingezi Suite magmatic activity that occurred between c. 3.5 and 2.75 Ga ago (Taylor et al. 1991; Wilson et al. 1995).

- ❖Classified into two main groups:

(1) Sodic plutons of the TTG and tonalitic gneisses of the Chingezi complex (Suite) (c. 2.98- 2.75: Martin, 1978; Taylor et al. 1991; Martin et al. 1993; Wilson et al. 1995; Orpen & Martin, 2017).

(2) Potassic plutons of the Chilimanzi Suite (c 2.60 Ga Chibi granite; small plutons west of the belt: Martin, 1978; Wilson et al. 1995).

- ❖Tonalitic compositions predominate over granitic rock types.

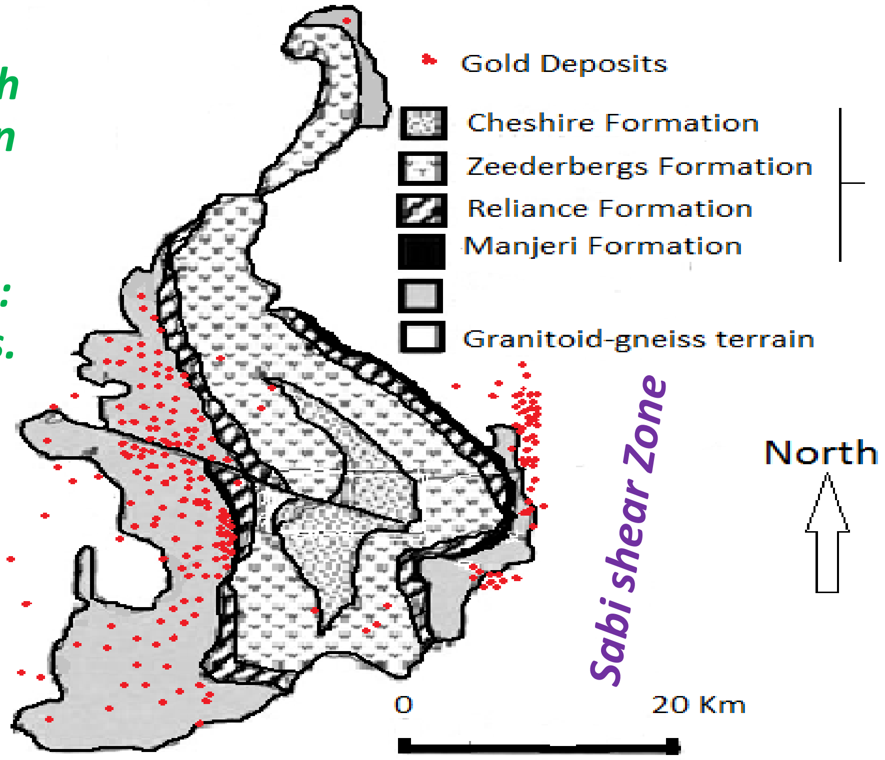
- ❖The Chingezi Suite: coeval products of the Belingwean (e.g., c. 2.91 Ga Hokonui Formation) and Lower Greenstones (e.g., c. 2.83 Ga Koodoovale Formation) felsic volcanism (Luais and Hawkesworth, 1994; Wilson et al. 1995).

Distribution of gold deposits in the Belingwe Belt (Mugumbate, 2017)

Generally small deposits < 100 kg each (Mugumbate, 2017)

Western part
Mineralization associated with
(a) N-S regional shear zones in greenstone rock units.

(b) ESE-WNW trending shears: related to granitoid intrusions.



(Hofmann & Chagondah, 2018)

Eastern part
N-S trending regional shear zone

- ***Shear zone straddles Shabani gneisses and Lower/ (Belingwean greenstones).***
- ***Sabi gold mine (>*** 5 tonnes of Au production) ***& associated small deposits and occurrences.***

Upper Bulawayan (UB) group: conspicuous paucity of gold deposits.

1. What does the scarcity of Au deposits in the UB group suggests?

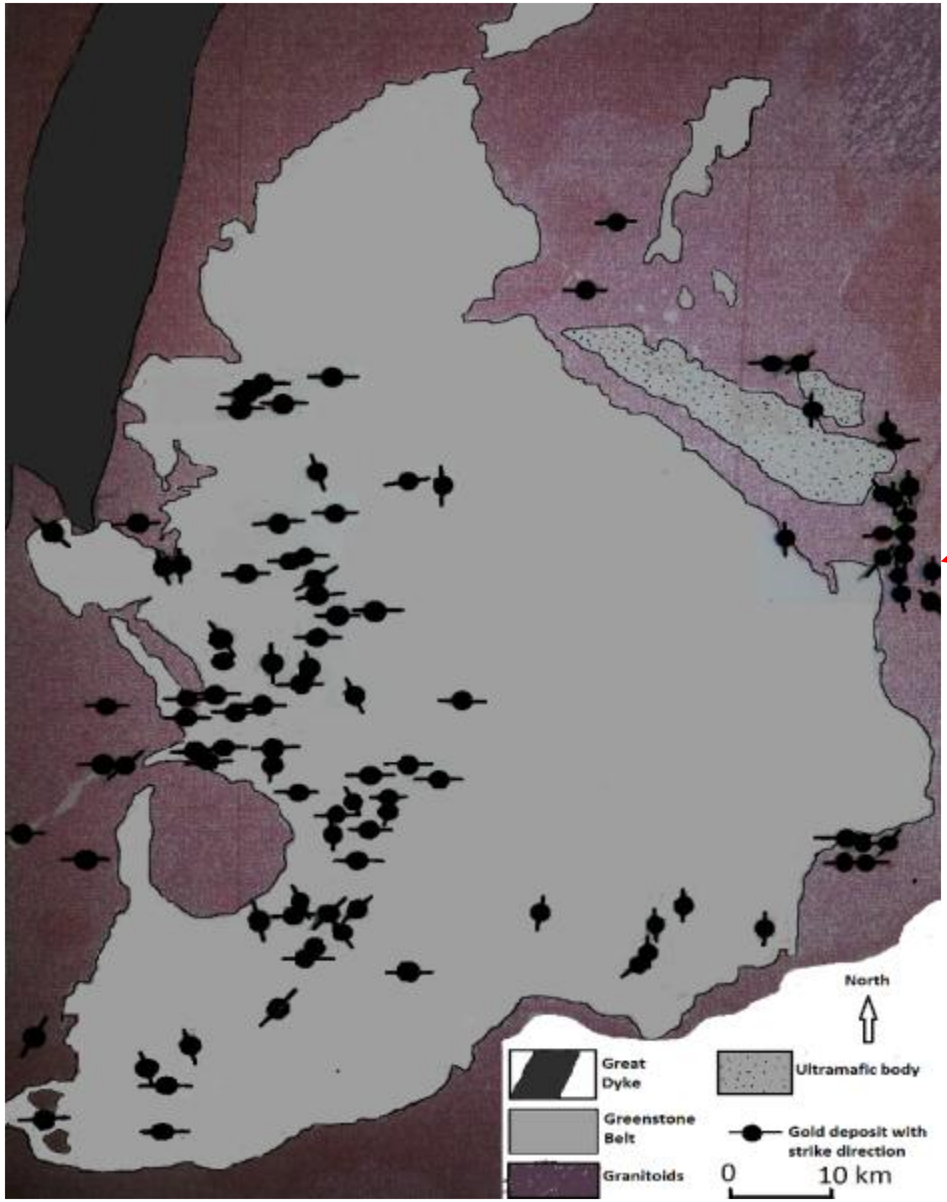
2. Does this indirectly cap the age of Au mineralization in the lower/ (Belingwean) greenstones?

3. Are we dealing with the "oldest" gold mineralization in Zimbabwe?

Strike directions of Au deposits in the Belingwe belt & surrounding granitoids

(from Mugumbate, 2017)

N-S and ESE shears



Sabi Shear Zone

c. 21 km long, brittle to brittle-ductile strain cutting the Shabani gneiss, Brooklands & Reliance Formations (Mugumbate, 2017).

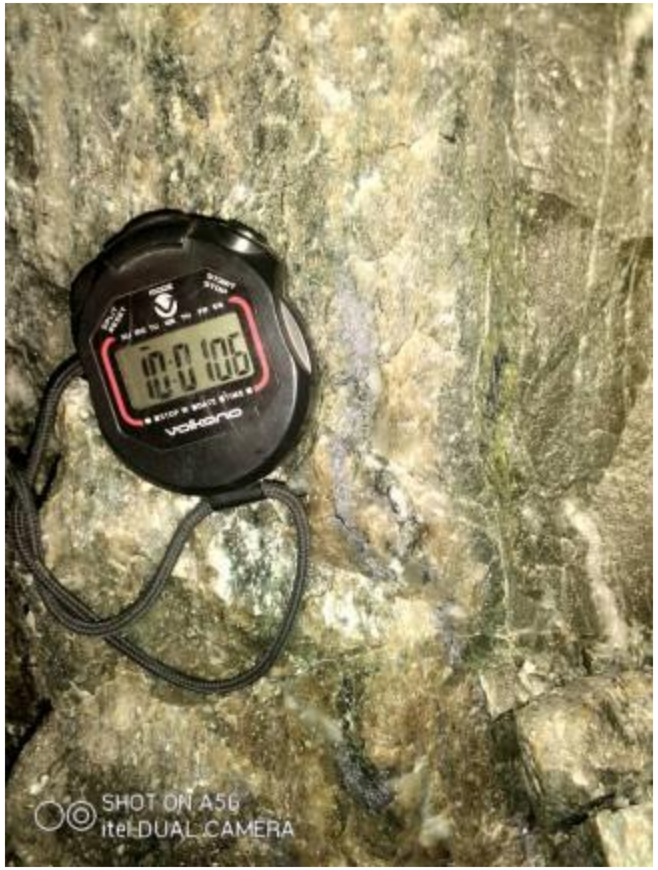
Field observations

- N-S shear zones in the Lower/ Belingwean greenstones are related to regional deformation.
- Granite intrusions (c. 5-20 m wide) display chilled margins = show high strain intensity (fracturing & shearing): shearing extends into the country rocks.
- Granites exhibit sheared margins & massive interiors = syn-kinematic granites (coeval shearing).
- WNW-ESE trending reefs are characterized by pervasive brittle-ductile structures related to shearing.
- ESE shearing related to granite plutonism truncates the N-S foliation, thus post-date regional deformation & metamorphism.
- Hydrothermal fluids circulation was likely facilitated by pervasive ductile structures (e.g., S-C fabric) related to the independent shearing episodes.
- The quartz-carbonate veins & stringers are concordant to foliation.
- The veins are banded or laminated at their margins & massive in the interior: sulphide mineralization (chalcopyrite, pyrite, galena, pyrrhotite & chalcopyrite) is along fractures.
- Syn-deformation mineralization.
- Mhindu (1998): note that some gold deposits occur at the intersections of lineaments.

Representative N-S shear system: Sabi Shear Zone

A: low grade oxide pit

B: underground drive

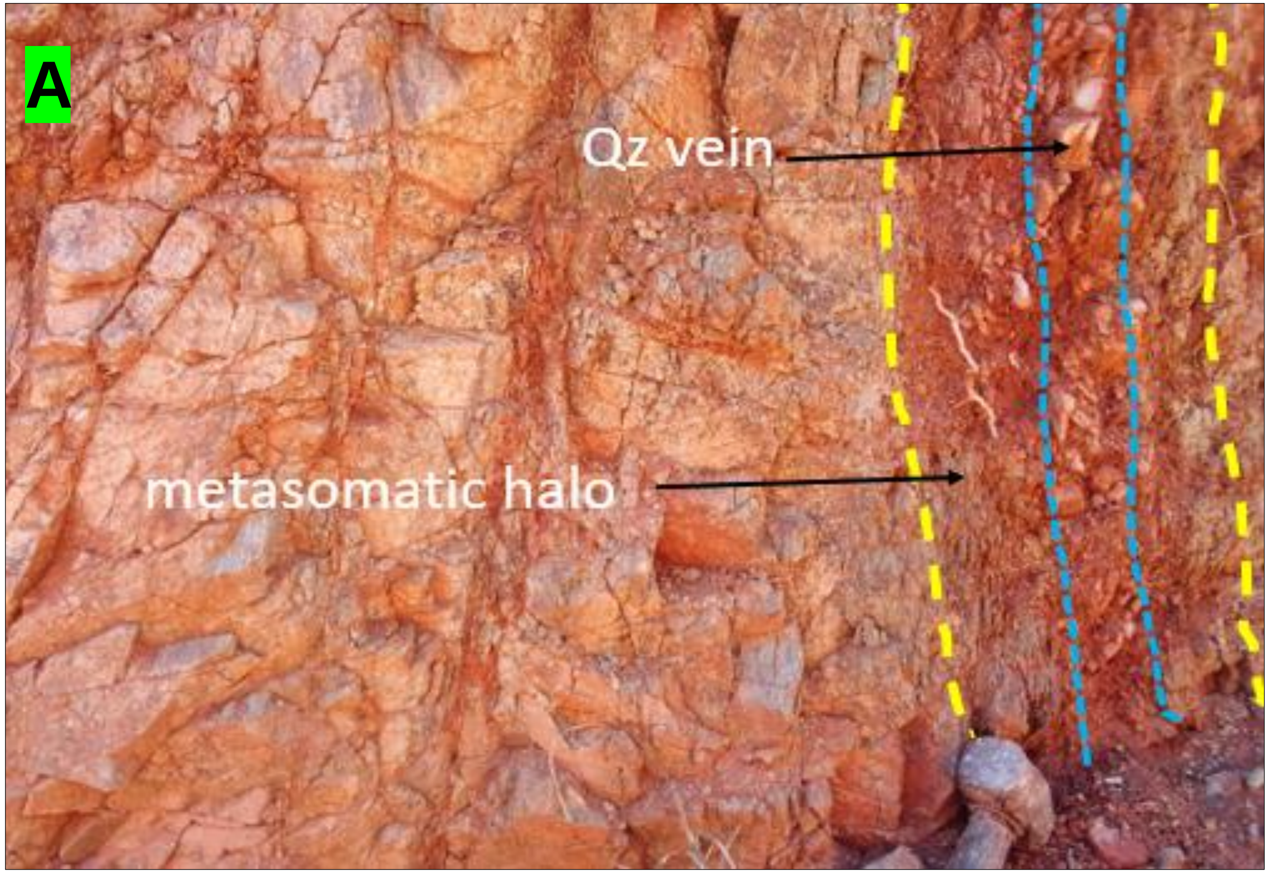


Courtesy: Hahlani

Representative N-S shear system looking N: Costas (West of Vanguard Mine)

Representative N-S shear system

A: Jumbo Mine (ATM section)



B: 1st level stope: Jumbo Mine

East-West shear system: C-mine

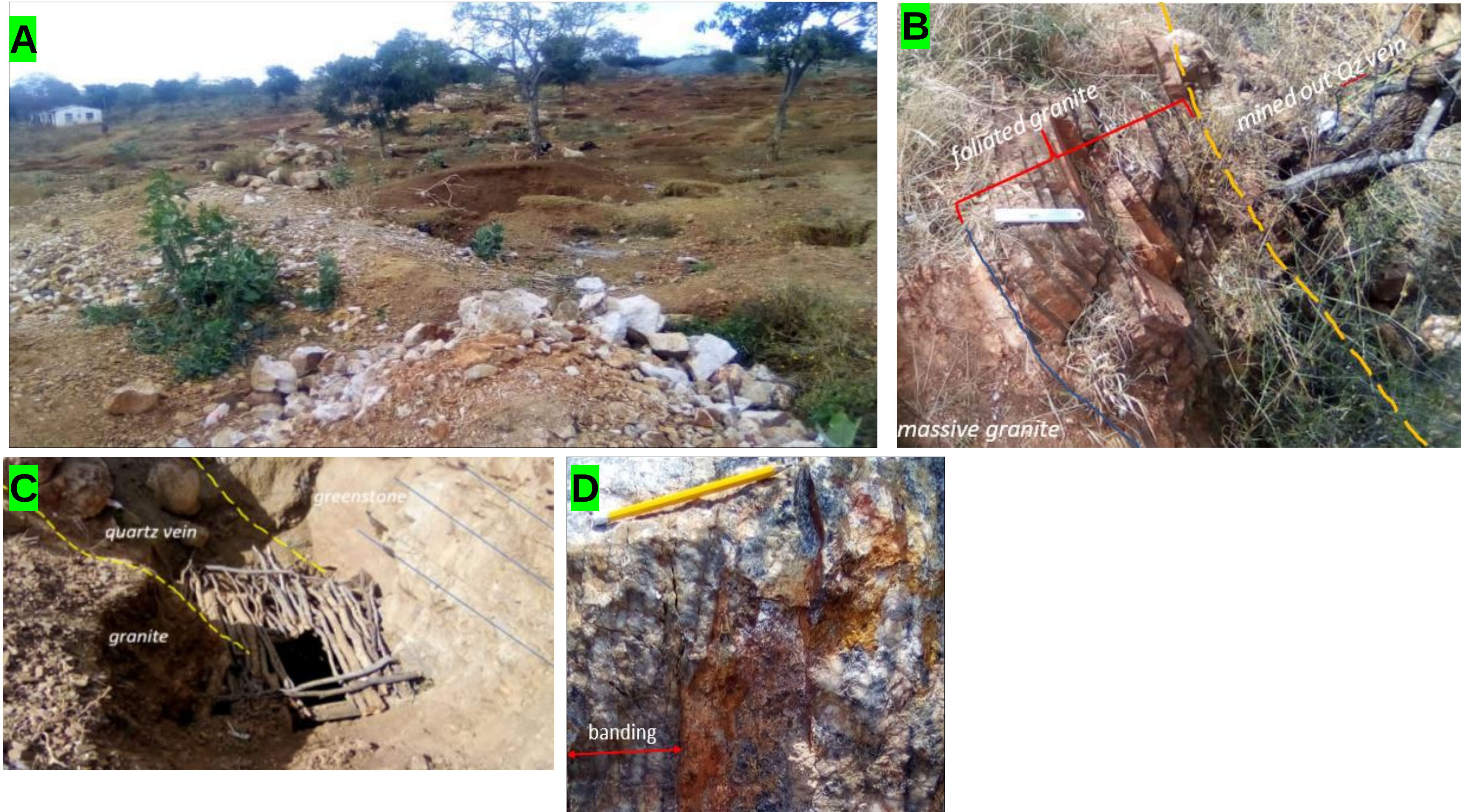
- > 1 tonne gold production recorded.
- Two sub parallel ESE striking reefs, dipping 70-80^{o} SW, c. 120 m apart.

(a) Northern reef: conspicuously massive white quartz vein up to 9-15m. Au mineralization confined on the HW: laminated or banded quartz. Quartz interior is massive & barren, whereas the margins are sheared.

- ❑ Tensile fracture-filling quartz (Mugumbate, 2017).
- ❑ Massive basaltic greenstones of the HF host the reef (Mugumbate, 2017).

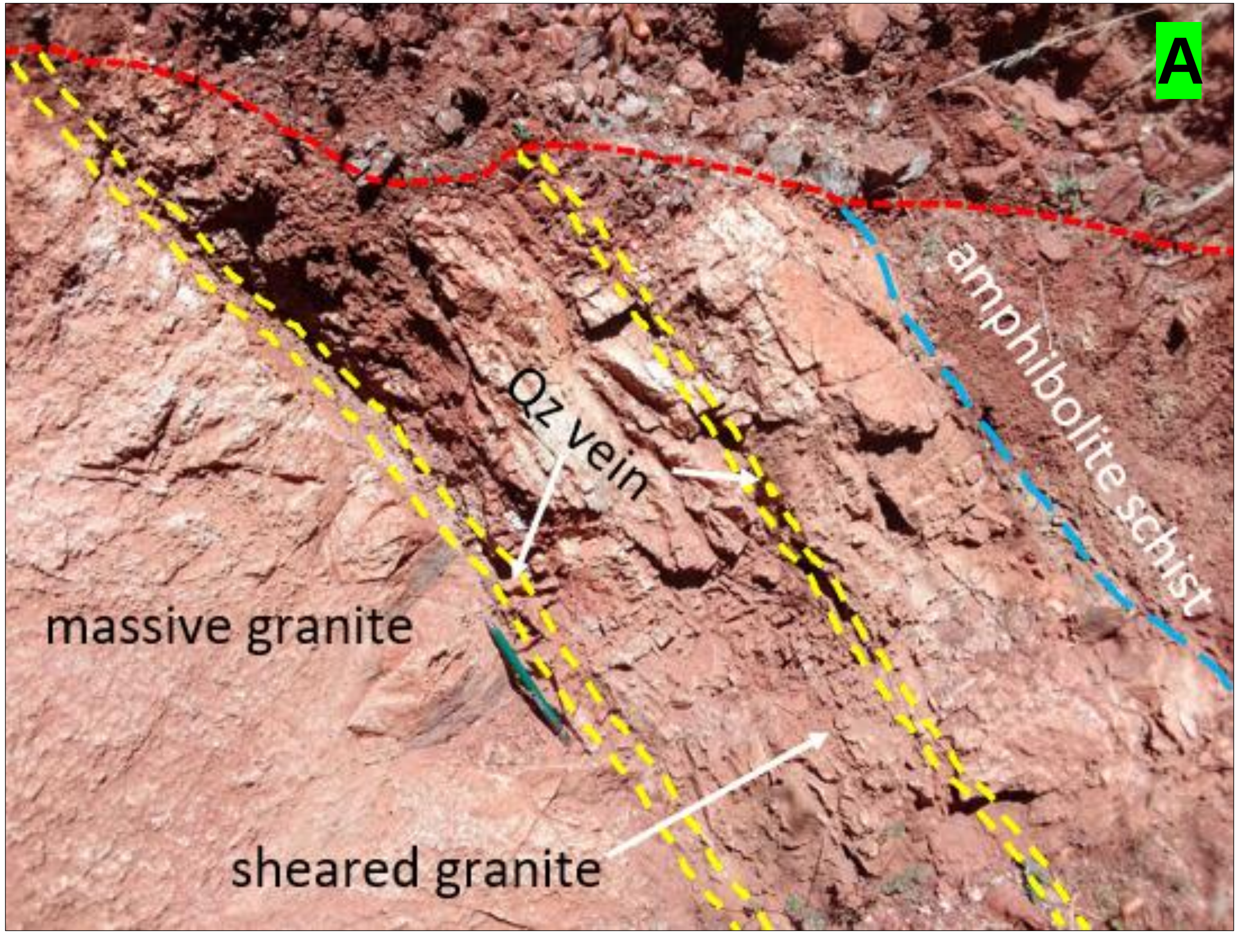
(b) Southern reef: laminated or banded quartz veins associated with sheared granite, HW > FW mineralization.

C-Mine

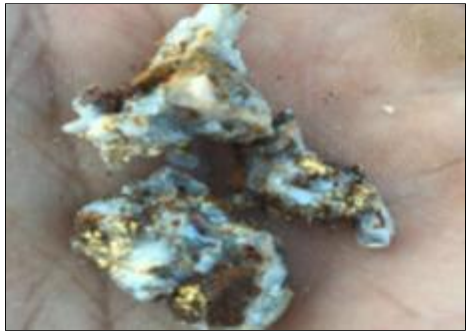

A
B
foliated granite
mined out Qz vein
massive granite
C
greenstone
quartz vein
granite
D
banding

East-West shear system: Jumbo Mine

A: KG Section looking E



B: lineament intersection: "pockets"



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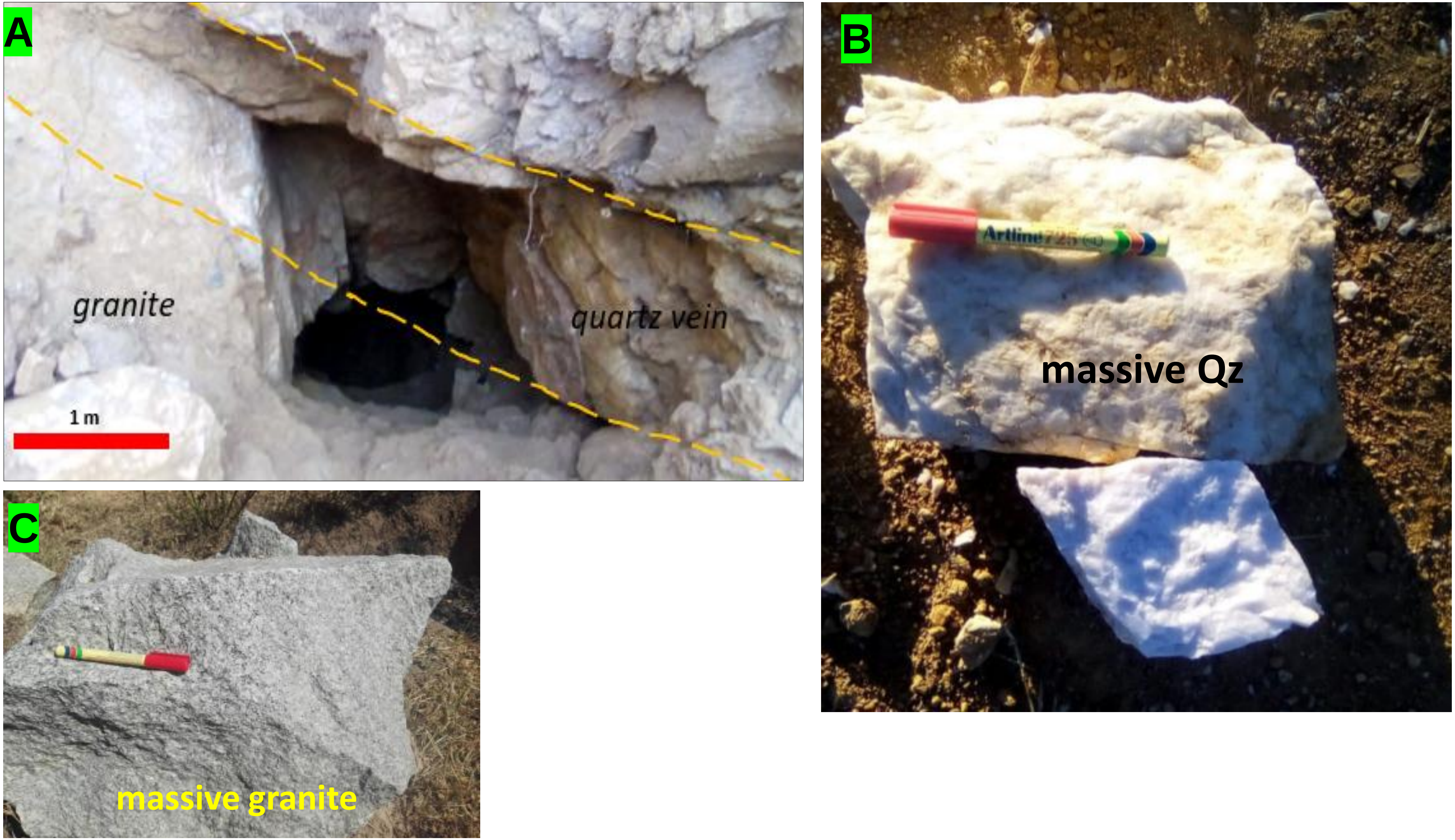
East-West shear system: D- Mine



East-West shear system : Cobert Mine

- ESE trending reefs.
- Reefs cross-cut prominent NNE structural grain indicated by gneissic fabric.
- Working suspended due to low grade: shear zone hosted in gneisses.

East-West shear system, looking East (Jumbo 8 claims: West of Vanguard Mine)

Not related to granite intrusion, Vanguard Ultramafic complex in the background

Note strong shearing on left of view which truncates regional N-S foliation

Discussion

- Shearing enhanced by competence contrasts of adjacent different rock types.
- Shearing extended to the immediate “basement” granitoids enveloping the greenstone belt.
- There is no mineralization in undeformed rock units across the belt including the Upper Bulawayan.
- brittle-ductile shear zones: shearing induced by granite intrusions enhanced hydrothermal fluid circulation: quartz-carbonate veins and stringers.
- Polyphases of Au mineralization envisaged; related to deformation & this is gleaned from

  (a) intersections of lineaments,

  (b) laminations or banding of reef margins,

  (c) mineralization in apparently massive quartz (e.g., D-mine) &

  (d) structures in the Sabi Shear Zone (Campbell & Pitfield, 1994).
- Au mineralization pre-dates Upper Bulawayan, with scarce mineralization in the latter attributed to re-activation of older shear systems.
- The WNW- ESE trending mineralization is shear hosted instead of extensional fracture-fill as proposed by Mugumbate (2017).
- Alternatively, they could be indeed fracture-fill with shearing occurring as a later event; this is unlikely as numerous deposits are clearly shear hosted.
- The major control of gold mineralization is the greenstone belt itself because granitoids further away display small concentrations or are not mineralized although shearing may be present.
- However, the “small contents” of mineralization in basement granitoids intruded by “younger granites” document a mineralization episode; which was superimposed & elevated Au concentration in the greenstones.
- The Mberengwa gold mineralization could be one of the oldest across the Zimbabwe craton.

Implications to exploration

- Mapping at local scale & distinguishing rock types is a powerful tool: “gold detector”.
- Ground magnetic surveys could be employed at local scale to contrast different rock types.
- Identification of N-S trending chlorite schists and ESE-WNW trending intersection of lineaments may take you closer to “pockets”.

Conclusions

- Higher Au mineralization in N-S trending shear zones relative to the ESE system.
- Chloritic schists host majority of ancient workings across N-S trending shear system.
- The ESE-WNW Chingezi Suite granitic intrusions are volumetrically small, & thus are unlikely to have been the source of gold.
- However, the intrusions are significant: catalyzed mineralization processes by providing competent rocks which enhanced shearing of country rocks and induced mineralization during deformation.
- Elevated Au values (or rather most frequent ancient workings) are intimately associated with intersections of chlorite schists & the ESE-trending shear systems.
- This explains the localization of ancient workings along the east-west strike traverses.
- It appears that there was enhanced circulation of Au-bearing fluids and/or gold remobilization at the lineament intersections.
- This echoes Mhindu (1998), who emphasized the importance of intersections & Au mineralization in deep seated structures across the mineralized sections of the belt.

Acknowledgements

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Thank You

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