Crustal Evolution of the Northern Part of the Kaapvaal Craton: Implications for Pietersburg Block Geodynamic Settings

Patience M Ratshalingwa1, Linda Iaccheri2 & Karen Smit3
School of Geosciences, University of the Witwatersrand, Johannesburg, South Africa.
2933006@students.wits.ac.za

1. INTRODUCTION

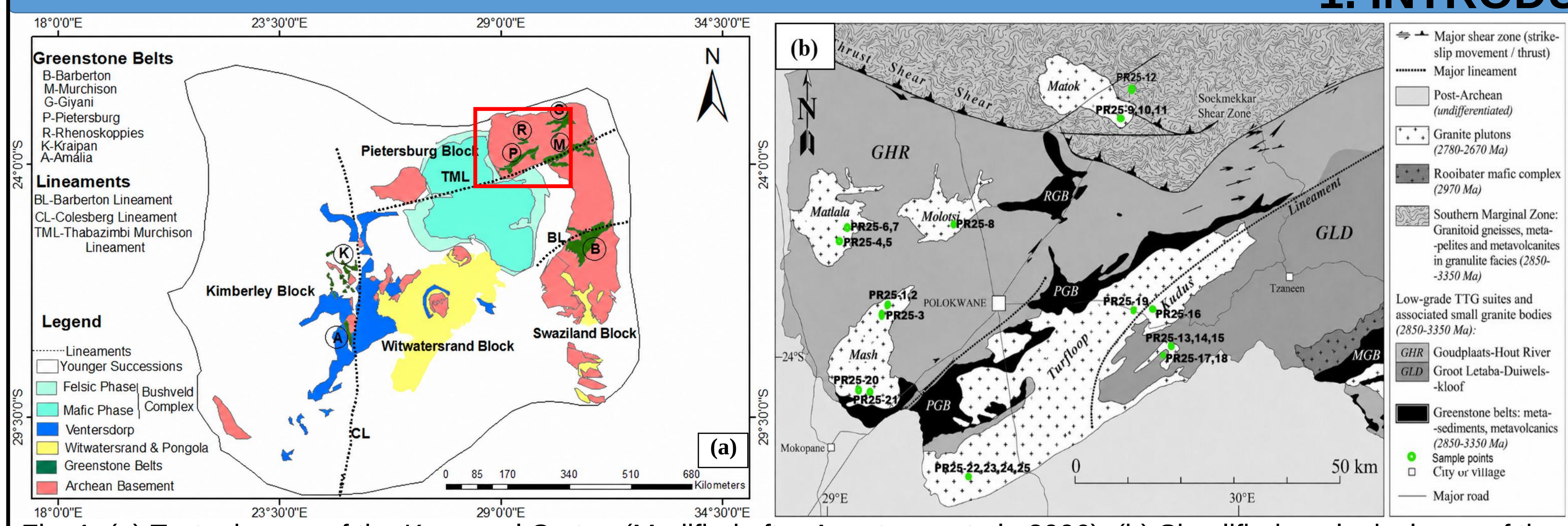

Fig. 1: (a) Tectonic map of the Kaapvaal Craton (Modified after Armstrong et al., 2006). (b) Simplified geological map of the Pietersburg block showing the major shear zone, greenstone belts and granitoids (from Laurent et al., 2014) with green circles indicating sampling points.

The Kaapvaal Craton has long been a focus of geological research due to its importance in understanding the early evolution of continental crust and Archean geodynamic processes. It preserves critical evidence of early Earth evolution and hosts significant mineral resources. The craton is subdivided into four crustal blocks: Swaziland, Witwatersrand, Kimberley, and Pietersburg (Fig. 1a). The northernmost Pietersburg Block is dominated by Mesoarchaean (ca. 3.15–2.85 Ga) to Neoarchaean granitoids comprising tonalite–trondhjemite–granodiorite (TTG) gneisses and potassic granitoids (Fig. 1b). Despite numerous studies on these TTGs and granitoids, the crustal and tectonic evolution of the Pietersburg Block remain poorly constrained. This study presents an integrated lithological, petrographic and geochemical investigation, combining field mapping, petrography, major (XRF) and trace elements (ICPMS) composition of representative granitoids from Mashashane, Matlala, Moletjie, Marsfontein, Tibane (west), Matok (north), and Turfloop (south) (Fig. 1b). The results are used to constrain the petrogenesis and geodynamic evolution of the Pietersburg Block.

2. RESULTS

2.1. Petrography

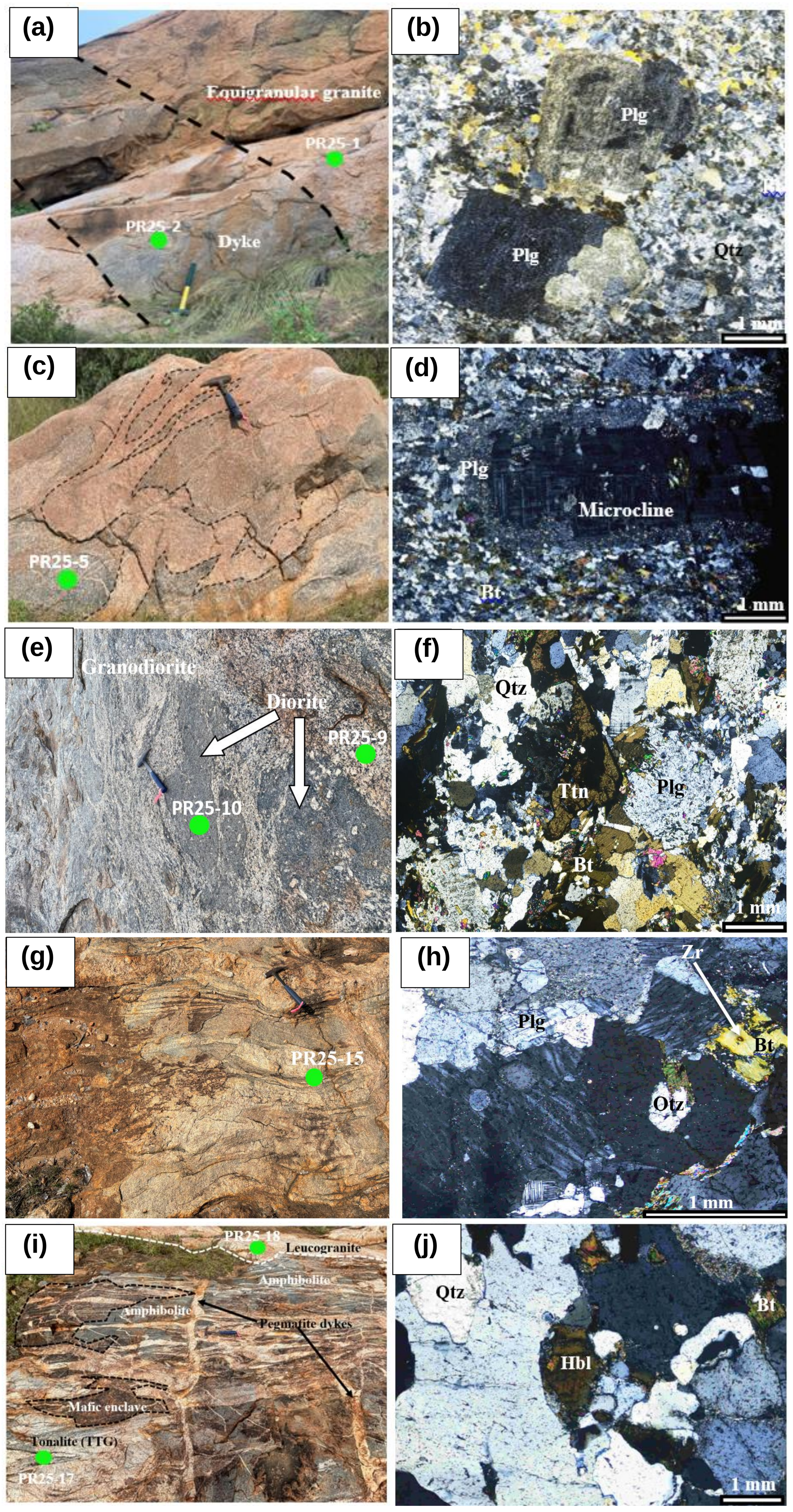

Fig. 2: Outcrop images and petrographic textures. (a-b) Mashashane granitoids. (c-d) Matlala granitoids. (e-f) Matok granitoids. (g-j) Turfloop granitoids/TTG outcrop. Abbreviations: Pl=Plagioclase; Qtz=Quartz; Bt=Biotite; Ttn=Titanite; Ox=Oxides; Hbl=Hornblende; Zr=Zircon.

- Western Pietersburg Block: Dominated by medium- to coarse-grained granites and granitic gneisses intruded by porphyritic dykes and pegmatite (Fig. 2a–d).
- Matok granitoids: Comprise deformed granodiorites with dioritic enclaves, intruded by monzogranite and pegmatite (Fig. 2e–f).
- Turfloop granitoids: Consist of TTG, granodiorite, granite, and leucogranite (Fig. 2g–h).TTGs are associated with amphibolite, mafic enclaves, and migmatitic textures, whereas the granites and leucogranites are more homogeneous and felsic.

2.2. Whole-rock Geochemistry

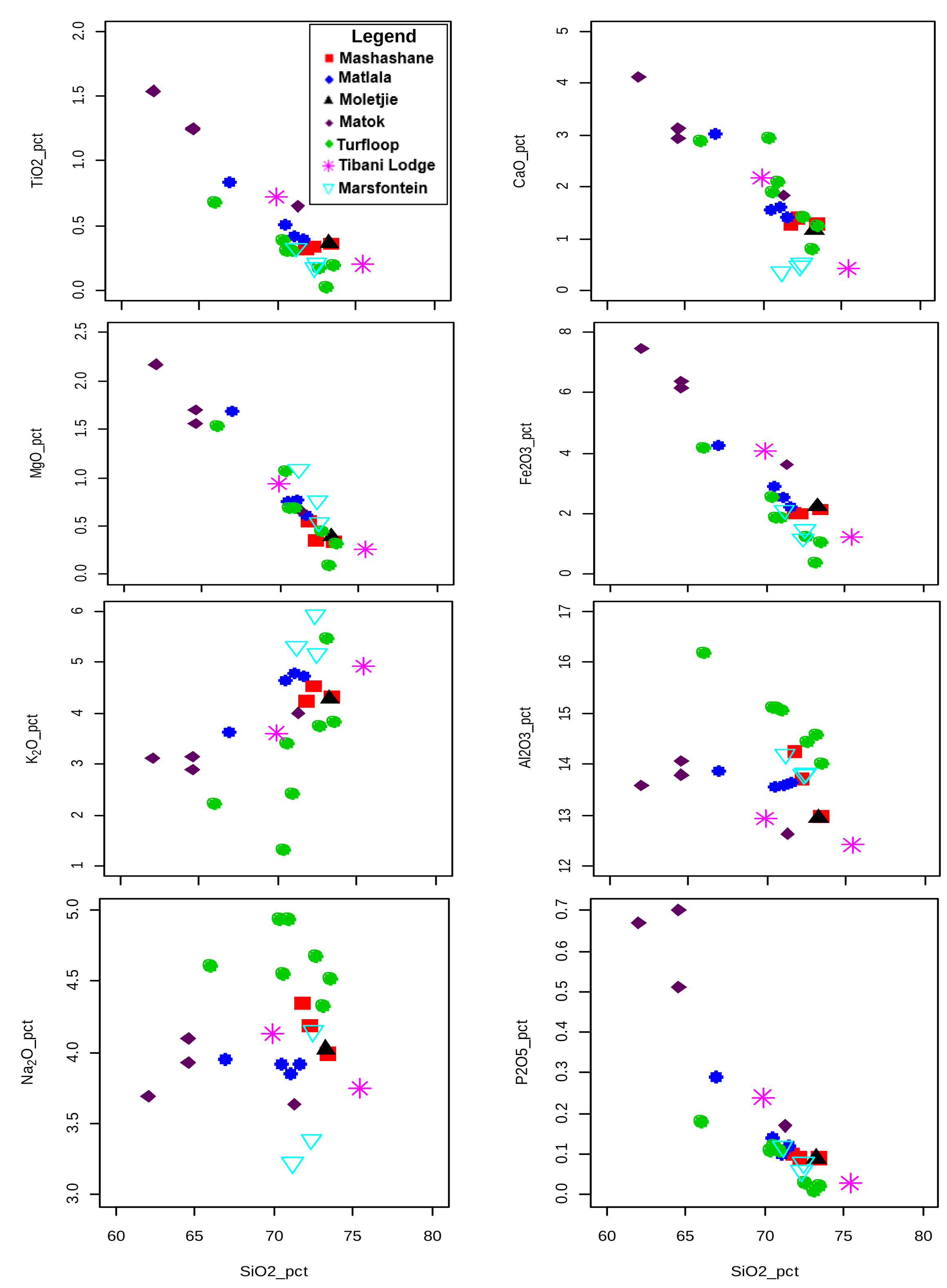

Fig. 3: Binary variation diagrams of SiO_2 versus major oxide concentrations for granitoids of the Pietersburg Block.

- Samples have SiO_2 contents of 62.05–75.41 wt.% with decreasing TiO_2, Fe_2O_3, MgO, CaO and P_2O_5 as SiO_2 increases (Fig.3).
- Matok granitoids: have lower SiO_2 and higher TiO_2, Fe_2O_3, MgO and CaO contents.
- Western Pietersburg granitoids: Higher SiO_2 and K_2O, indicating more evolved, K-rich magmas. .
- Turfloop granitoids: High SiO_2 and Al_2O_3, low K_2O, and high Na_2O/K_2O ratios, consistent with TTG affinity.

- K-rich granitoids: Have steep LREE-enriched, flat HREE patterns with negative Eu anomalies, relatively higher HREE (higher Yb), and less fractionated REE patterns (Fig. 4a–b).
- Na-rich Turfloop granitoids (TTGs): Have steep REE patterns with depleted HREE (low Yb) and positive to flat Eu anomalies(Fig. 4c–d).

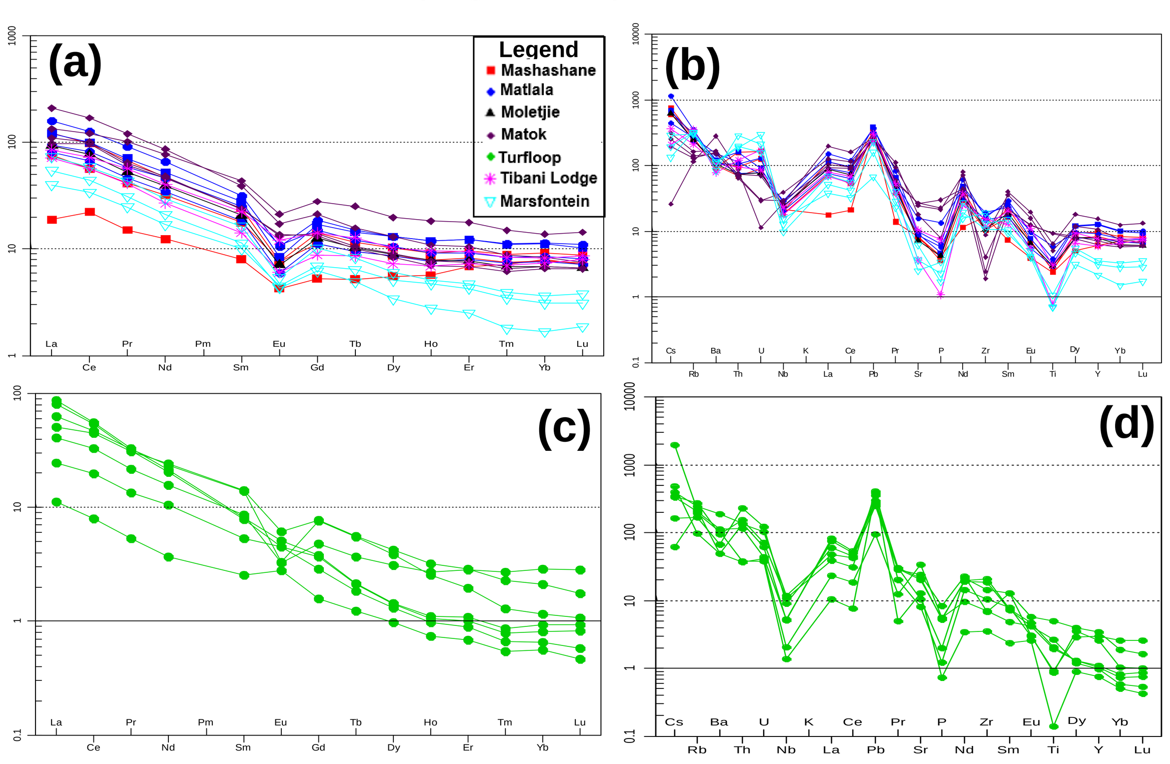

Fig. 4: Chondrite–normalized REE patterns and primitive mantle–normalized trace–element spider diagrams (Sun and McDonough, 1989).

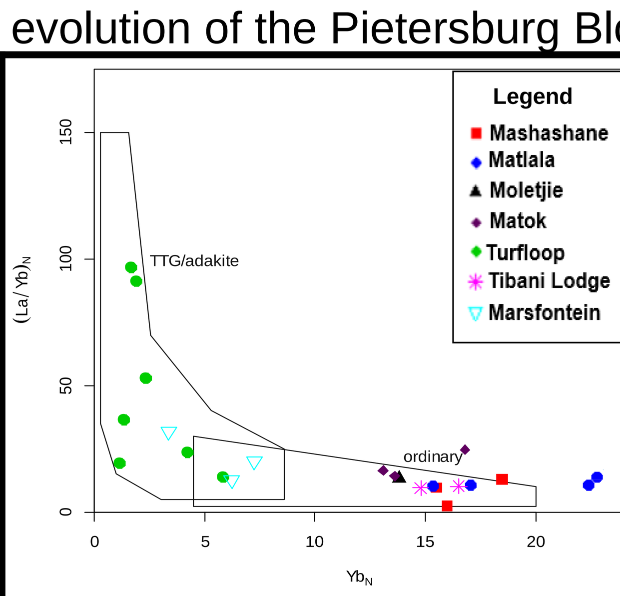

Fig. 5: (La/Yb)N versus YbN diagram (Martin,1986).

- Turfloop and Marsfontein samples have TTG Archaean affinity. K-rich granitoids plot in the ordinary field (Fig.5).

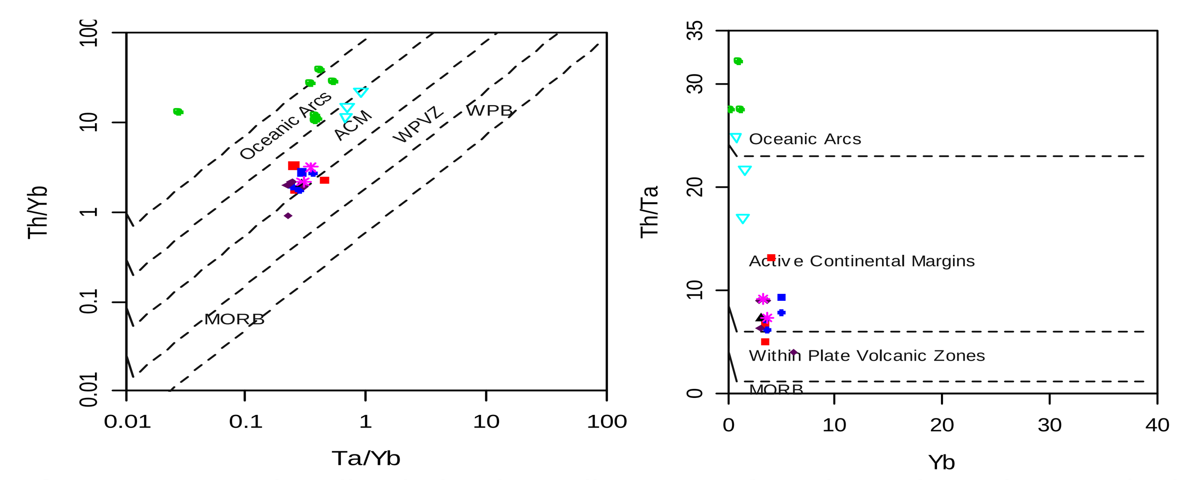

Fig. 6: Tectonic discrimination diagrams for the Pietersburg Block granitoids. The legend is the same as Fig. 5.

3. DISCUSSION AND CONCLUSION

3.1. Tectonic Setting

Evolution of the Pietersburg Block (ca. **2.97–2.67 Ga**)

- **Stage 1 (2.97–2.85 Ga):** Formation of juvenile TTG crust (e.g., tonalite PR25-17).
- **Stage 2 (2.85–2.75 Ga):** Partial melting of TTGs produced the Turfloop granitoids, displaying oceanic arc geochemical signatures (Fig. 6).
- **Stage 3 (2.75–2.69 Ga):** Emplacement of K-rich granitoids (Mashashane, Matlala, Moletjie, Tibane Lodge and Marsfontein) representing continental arc magmatism.
- **Final Stage (2.69–2.67 Ga):** Intrusion of Matok diorites and porphyritic dykes with within-plate geochemical affinities (Fig.6).

These magmatic stages suggest progressive crustal growth and stabilization of the Pietersburg Block through accretionary processes along the Thabazimbi–Murchison Lineament, involving tectonic switching from an oceanic arc to a continental arc and subsequently to a post-arc extensional regime (Fig. 7) (Laurent et al., 2019).

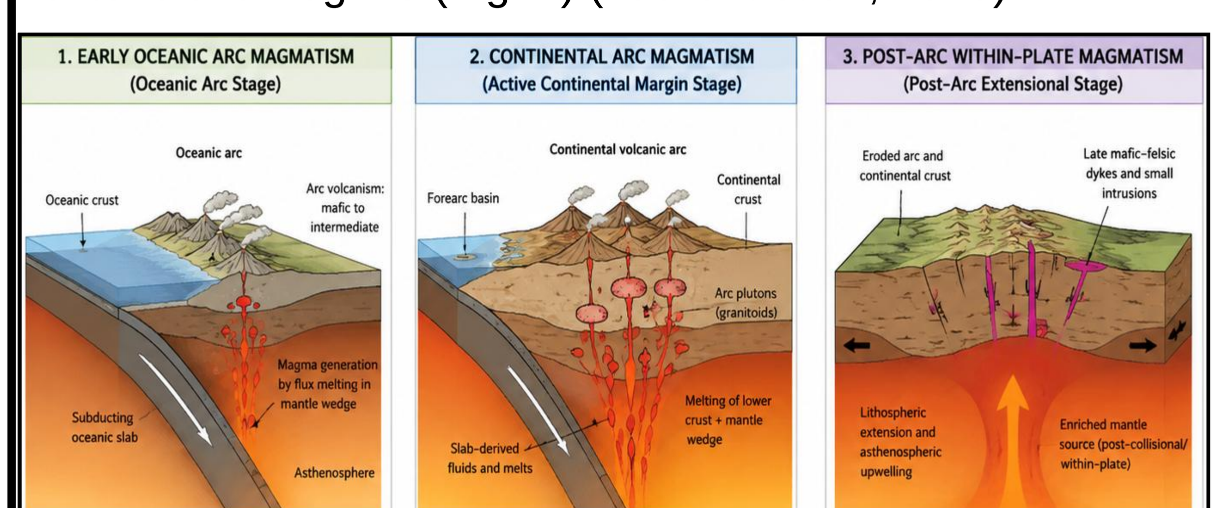

Fig. 7: Schematic tectono-magmatic evolution model for the Pietersburg Block showing stages of magmatism. (1) Early oceanic arc magmatism (2) Continental arc magmatism (3) Post-arc within-plate magmatism (After Stern & Whattam, 2015).

5. ACKNOWLEDGEMENTS

- DSI-NRF CIMERA for running costs
- AGATE scholarship for funding the conference costs including registration, travelling and accommodation.

6. REFERENCES

Scan for references

Structural Geology in a Changing World: Tectonics, Resources and Sustainable Transition