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The petrogenesis of orbicular granites in the Diana's Pool area, Zimbabwe.

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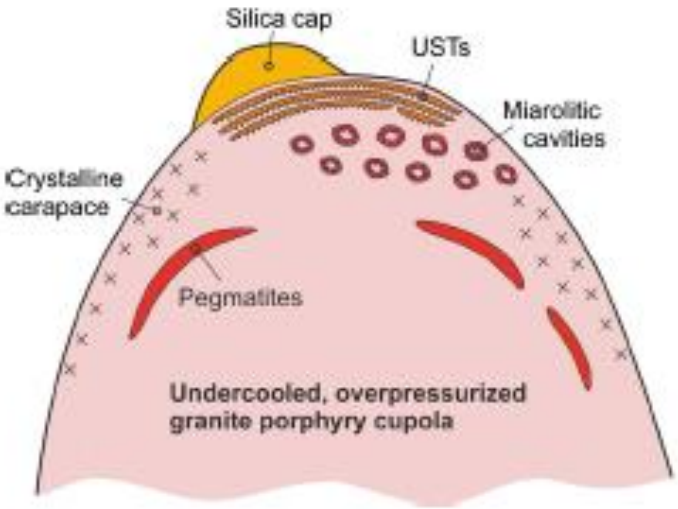
Orbicule Kopjie, Northern Cape

Orbicules from Finland

Orbicular diorite from Corsica



Muller et al., 2023

Typically occur in marginal or roof facies

Background

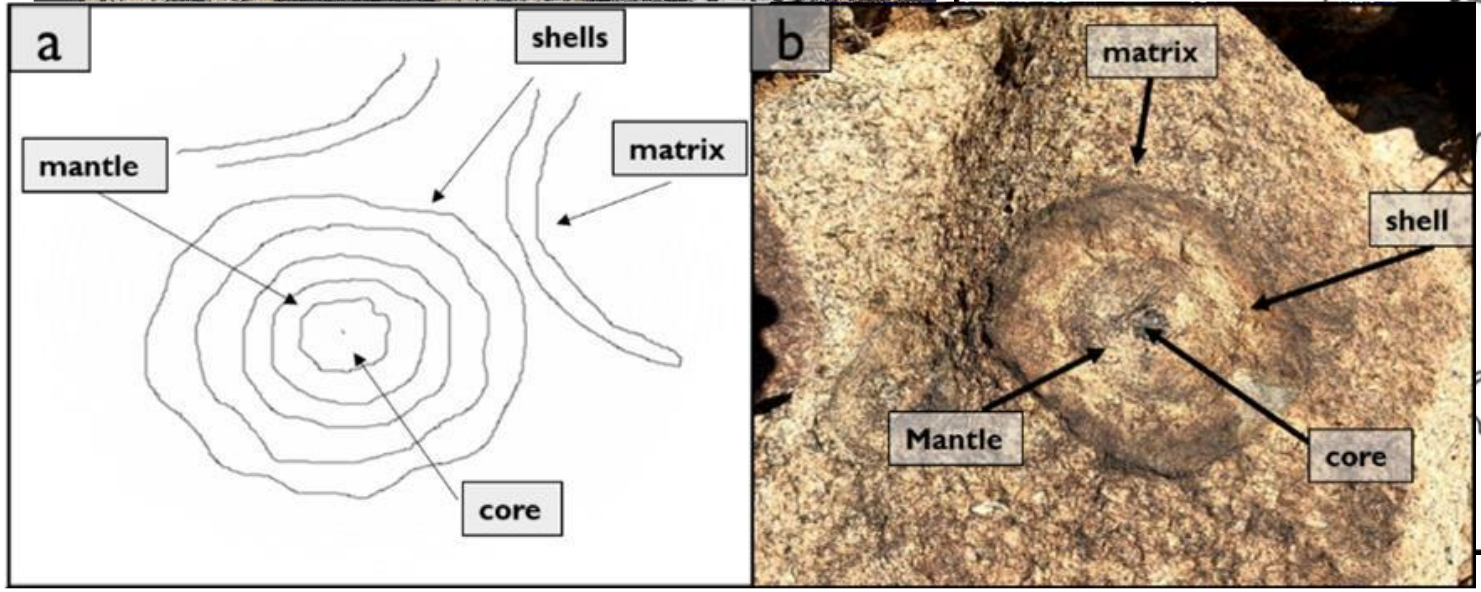
MicroXRF image of rock slice from Diana's Pool

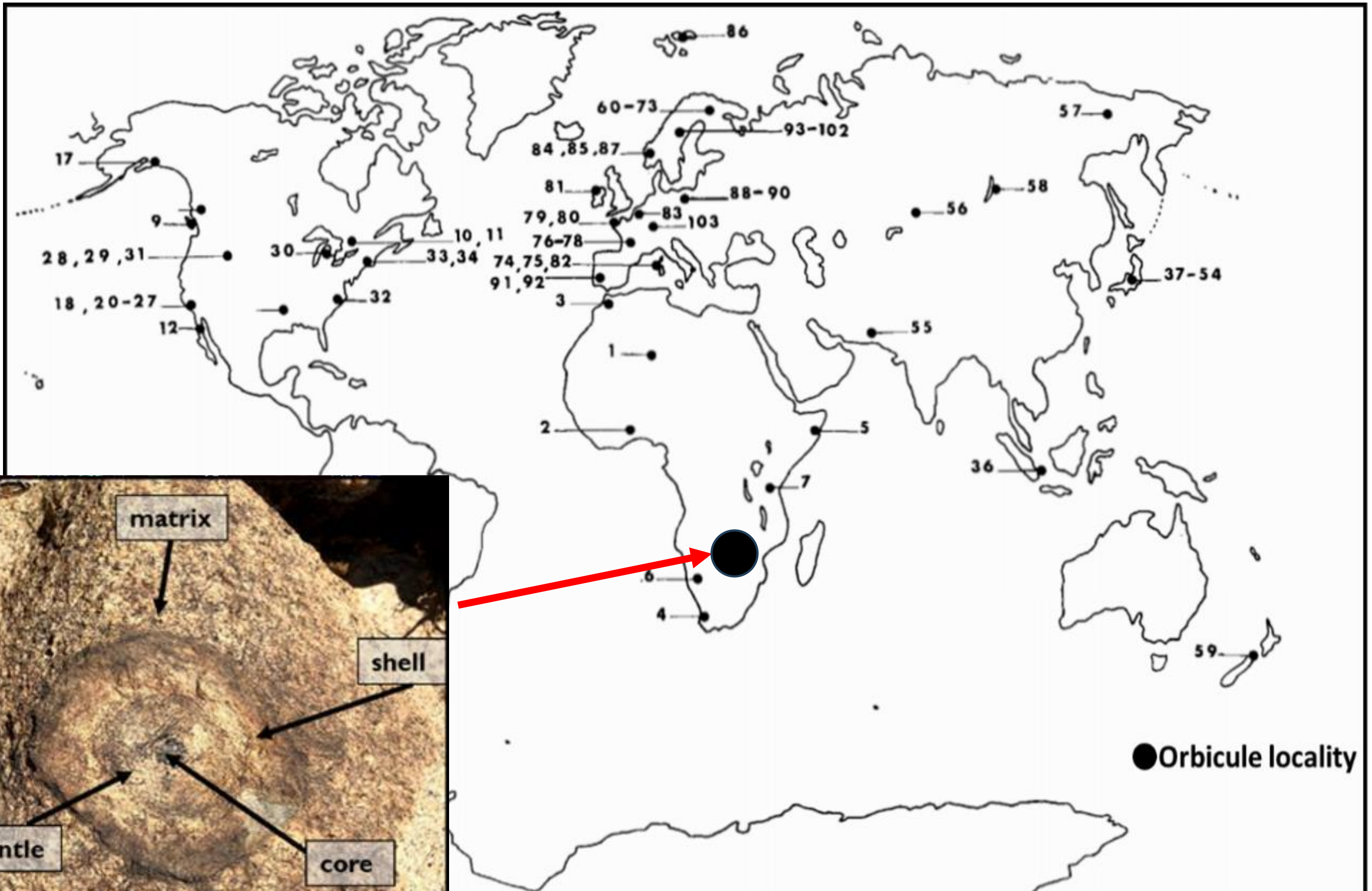
- Orbicular rocks were first discovered in the early 1800s
- Received attention because of their beauty and scarcity
- Study focuses on the poorly studied orbicular granites in the Diana's Pool area

Background and Problem Statement

- What and where are orbicular rocks?

Mt Magnet, Australia

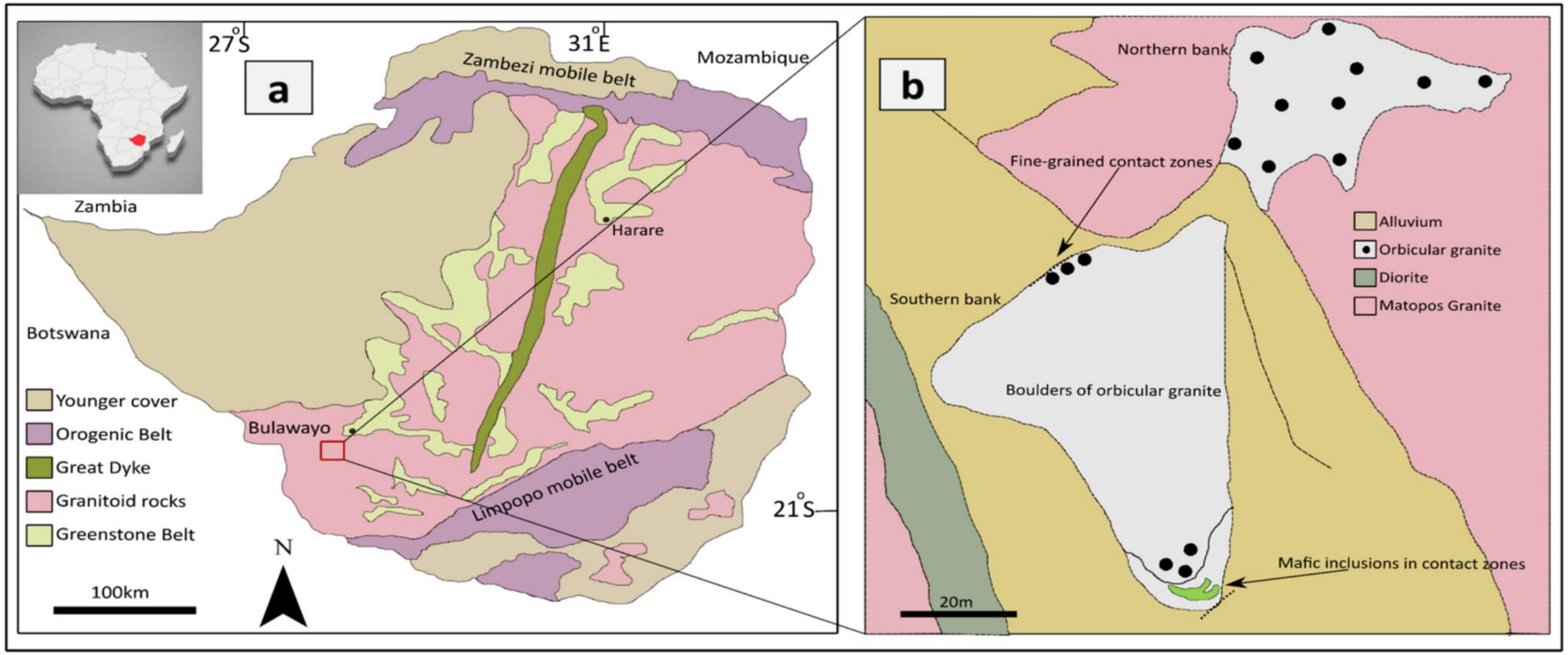




(Leveson, 1966)

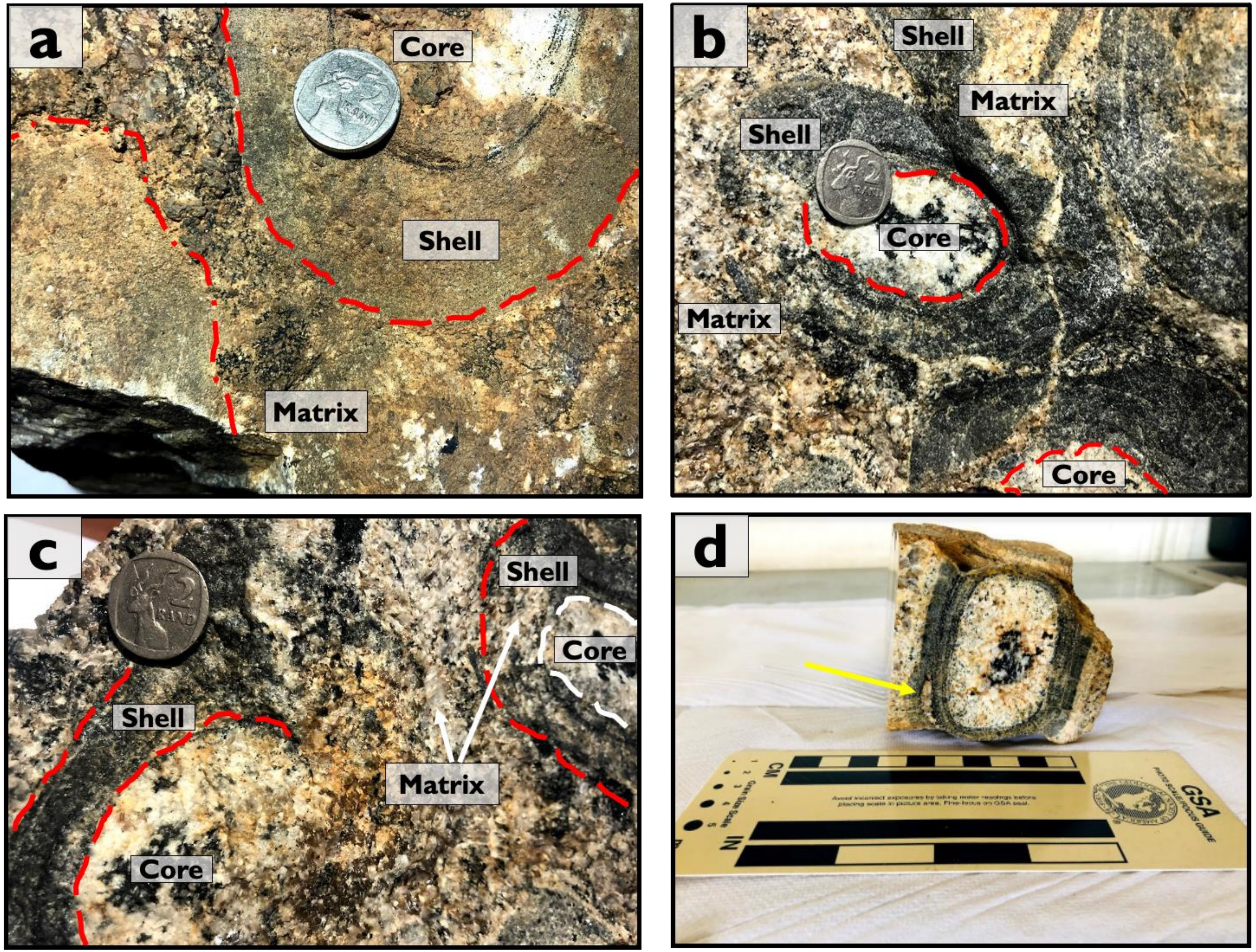
Geological Setting

- 2 known orbicular localities in Zimbabwe:
  - (1) One at Diana's Pool,
  - (2) the other 5 km SSE of the Mpopoma dam
- The Diana's Pool orbicular granite occurs within the Matobo Hills World Heritage site
- 30 km south of Bulawayo, Zimbabwe
- Occurs within the Matopos granite of the 2.65 Ga Chilimanzi granite Suite that intrudes the Archean granite greenstone making up the Zimbabwean Craton



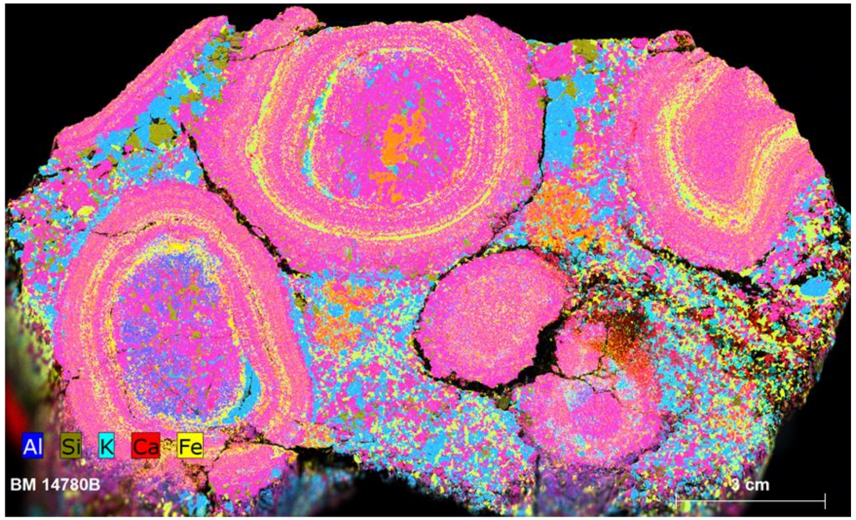
Modified after Garson (1995)

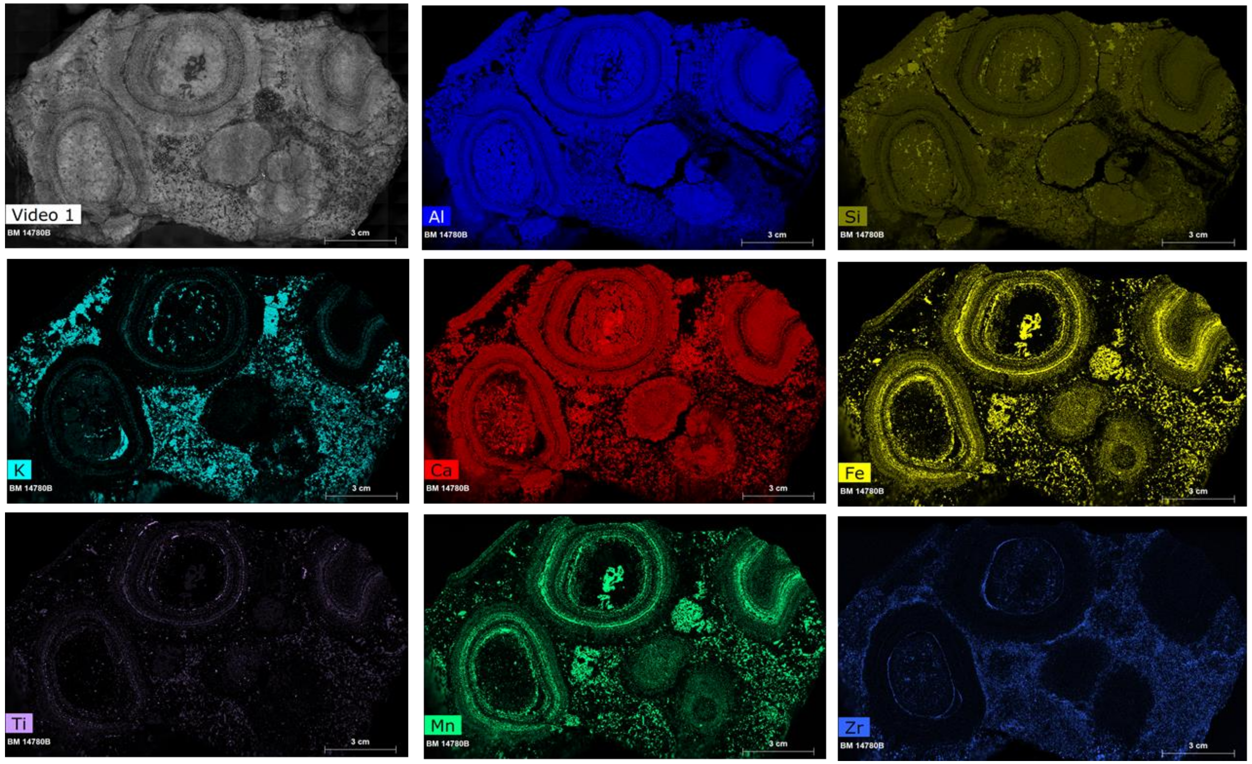
Hand Sample descriptions



- Hand samples from Diana's Pool in the Wits Bleloch Museum collection
- Closely packed orbicules in a granitic matrix
- 9-14 cm in diameter
- Contain coarse-grained cores, fine-grained and alternating ferromagnesian and feldspathic shells, and a coarse-grained matrix
- Generally spherical to ellipsoidal in shape
- Some appear to be abraded and deformed

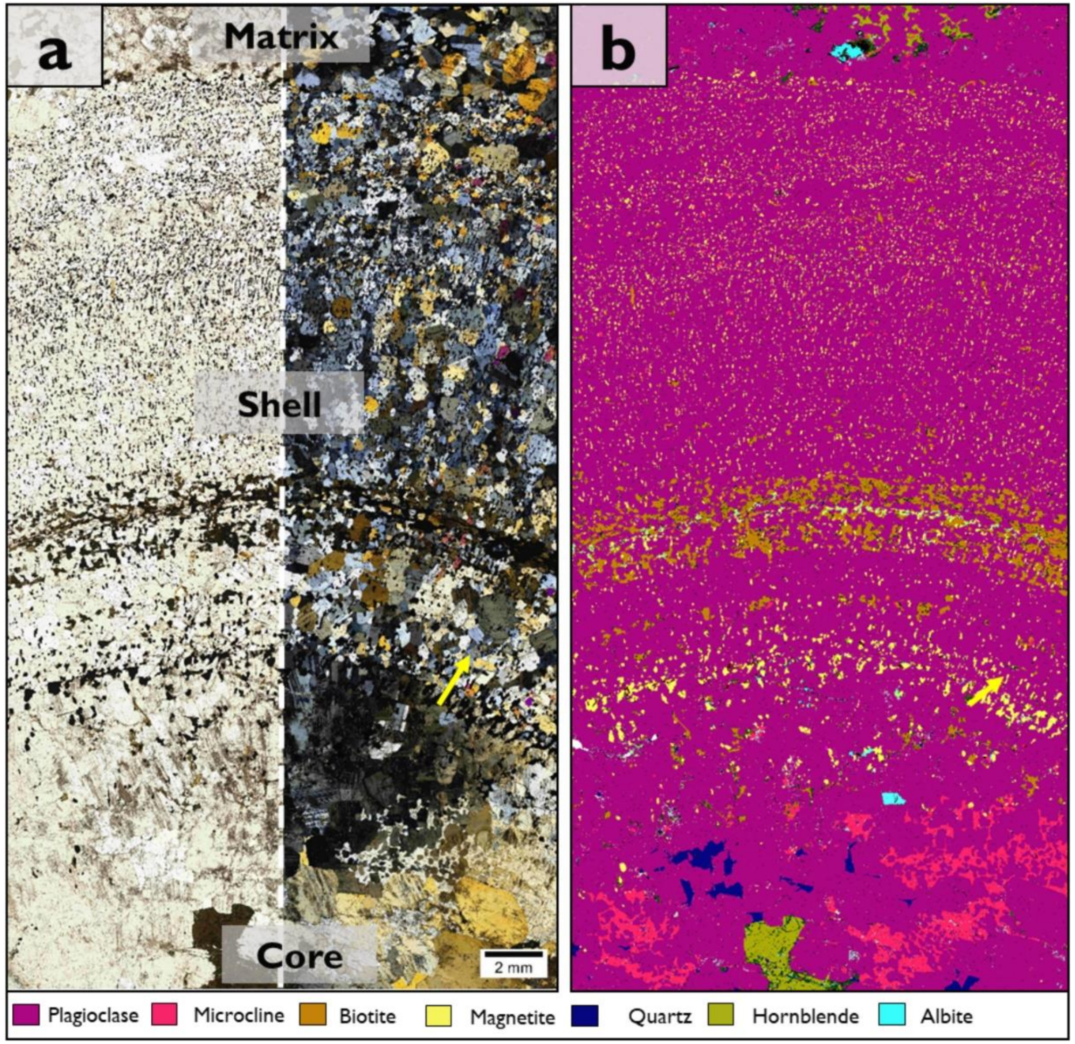
Macroscopic Geochemistry



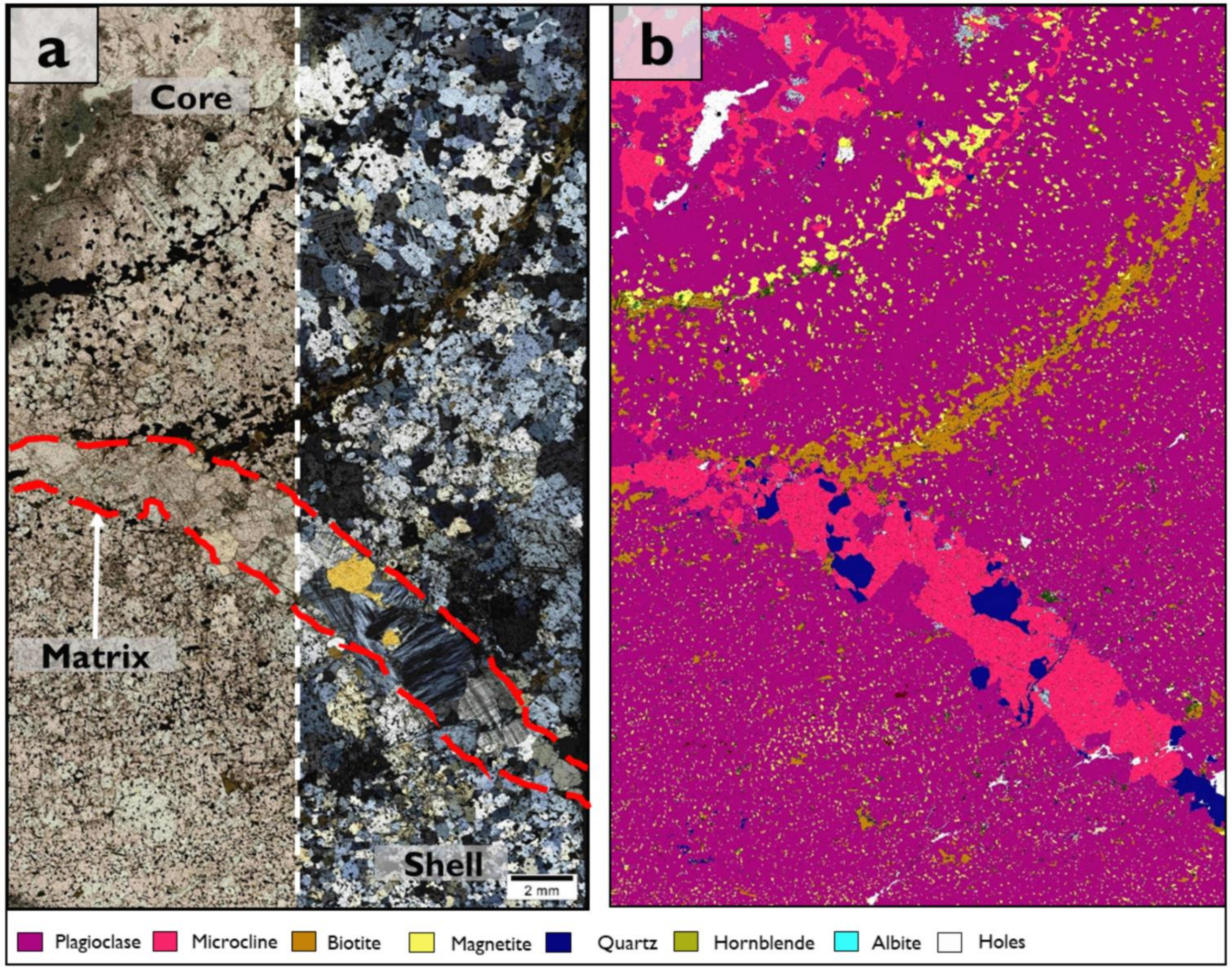


- Micro-XRF imaging provides complimentary information at a large scale of observation
- Cut surfaces are all that is required, non-destructive
- Cores and matrices are both felsic while the shells are more mafic
- Matrix and cores are more coarse-grained than the shells
- Cores and shells lack K

Thin Section and TIMA Observations

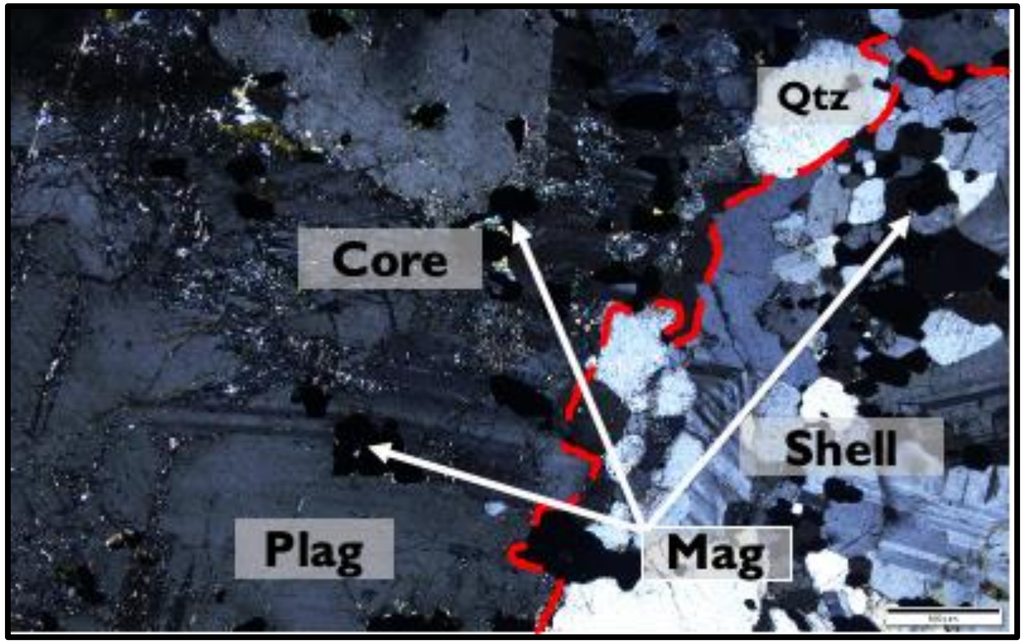


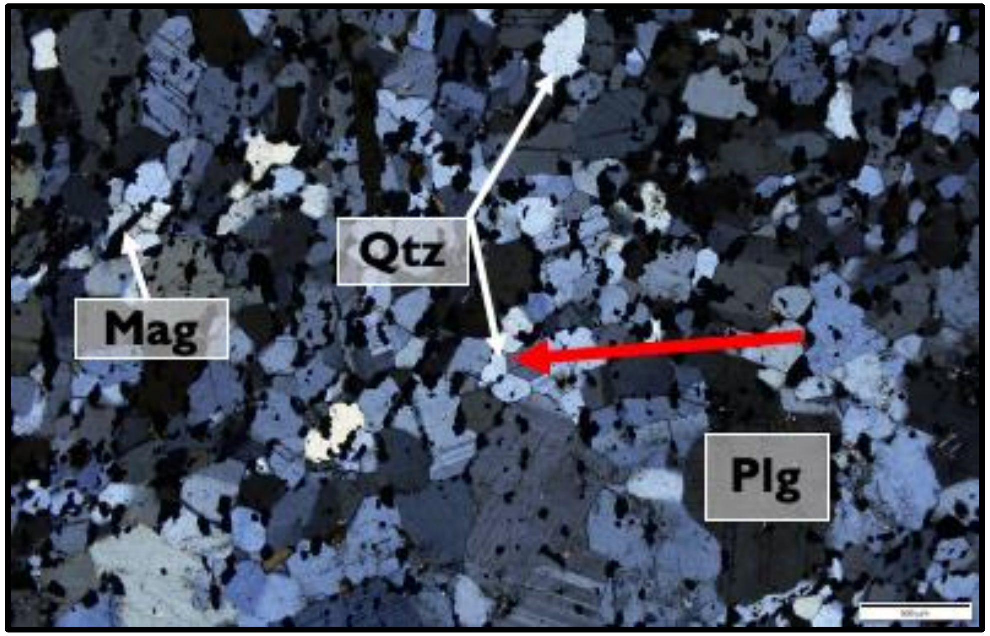
Shells are finer-grained than cores and matrices, contain biotite and radiating magnetite.
Occasional hornblende only occurs within the cores and matrix

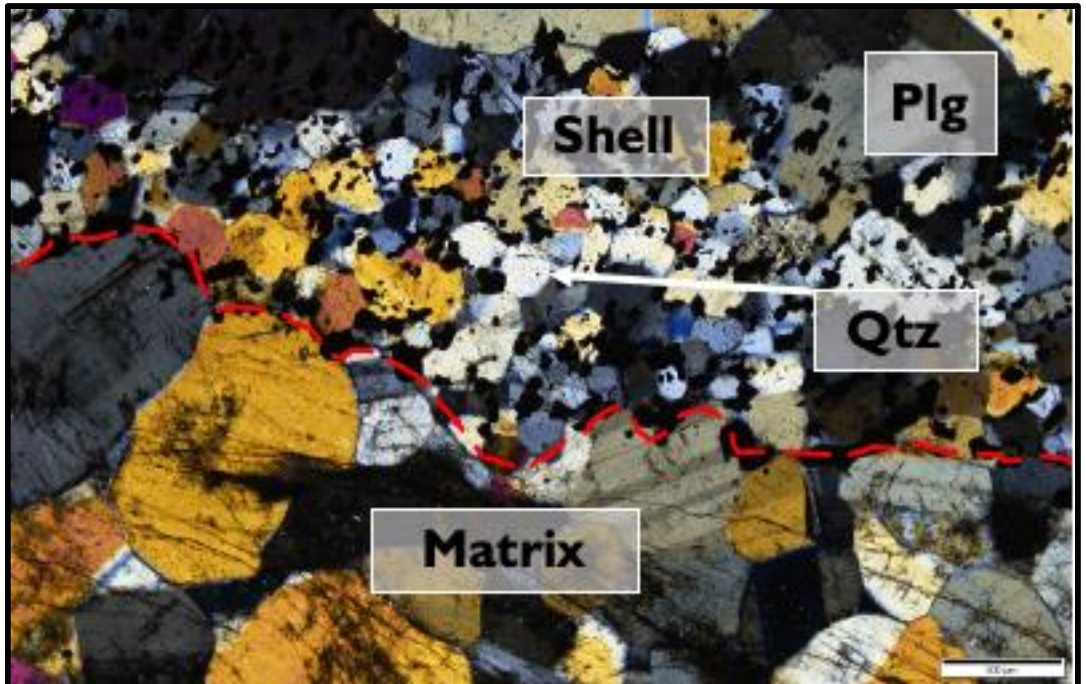


Microcline in matrix appears to cross-cut the shells

At thin section scale



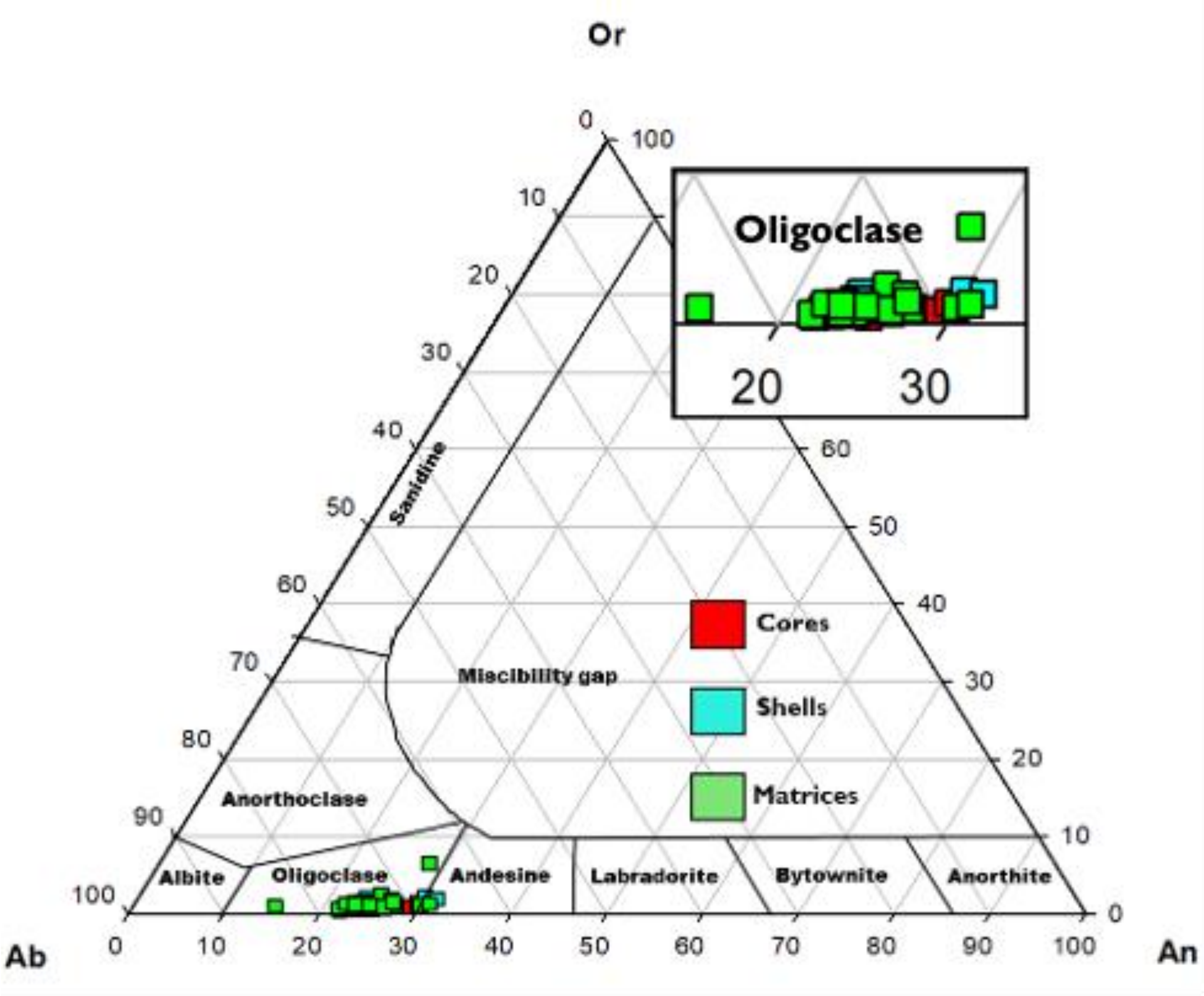




- Different textures in shells compared to cores and matrices
- Coarse-grained and felsic cores and matrix
- Sharp contacts
- Fine-grained mafic shells exhibiting polygonal and radiating textures

Mineral chemistry

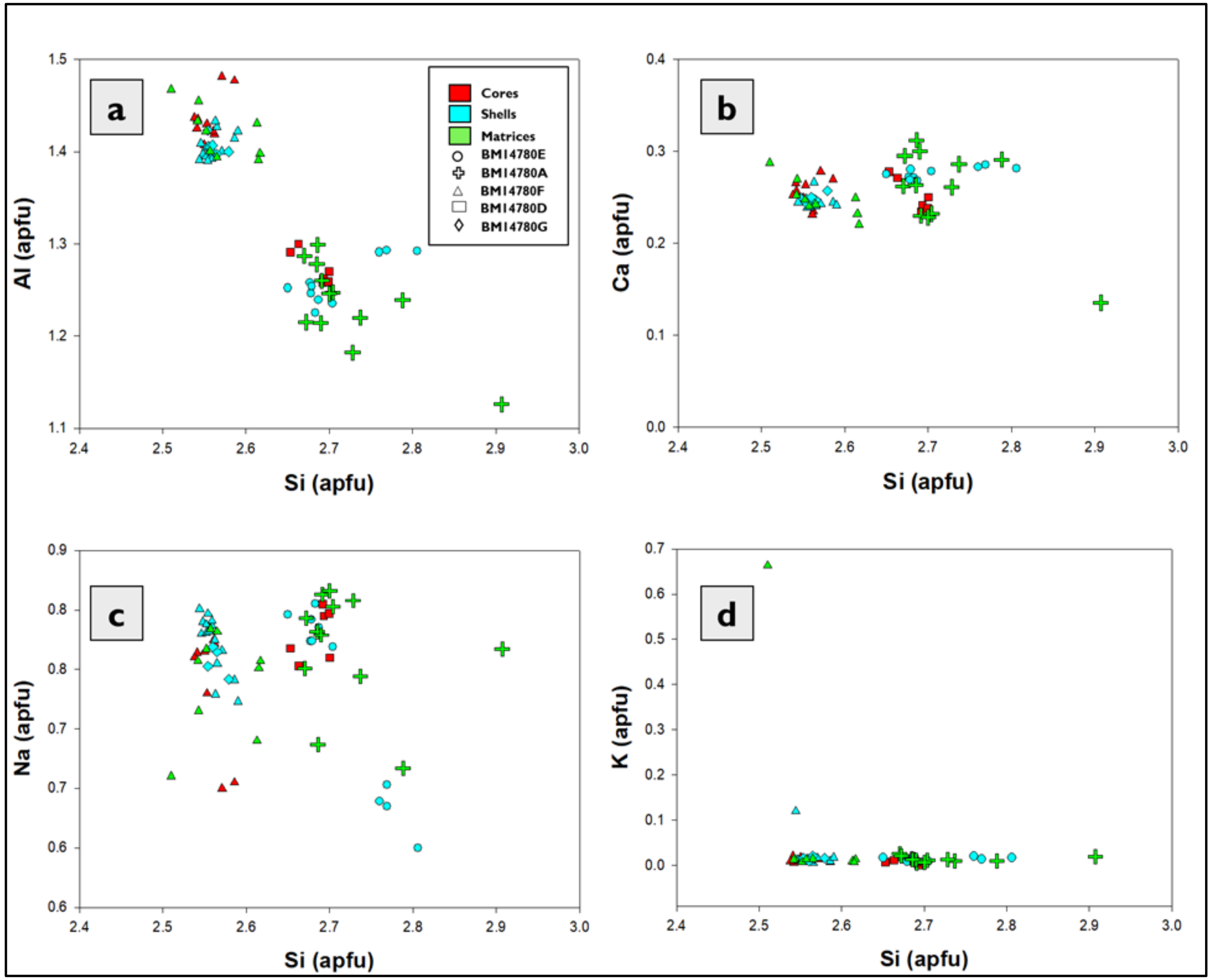
Plagioclase

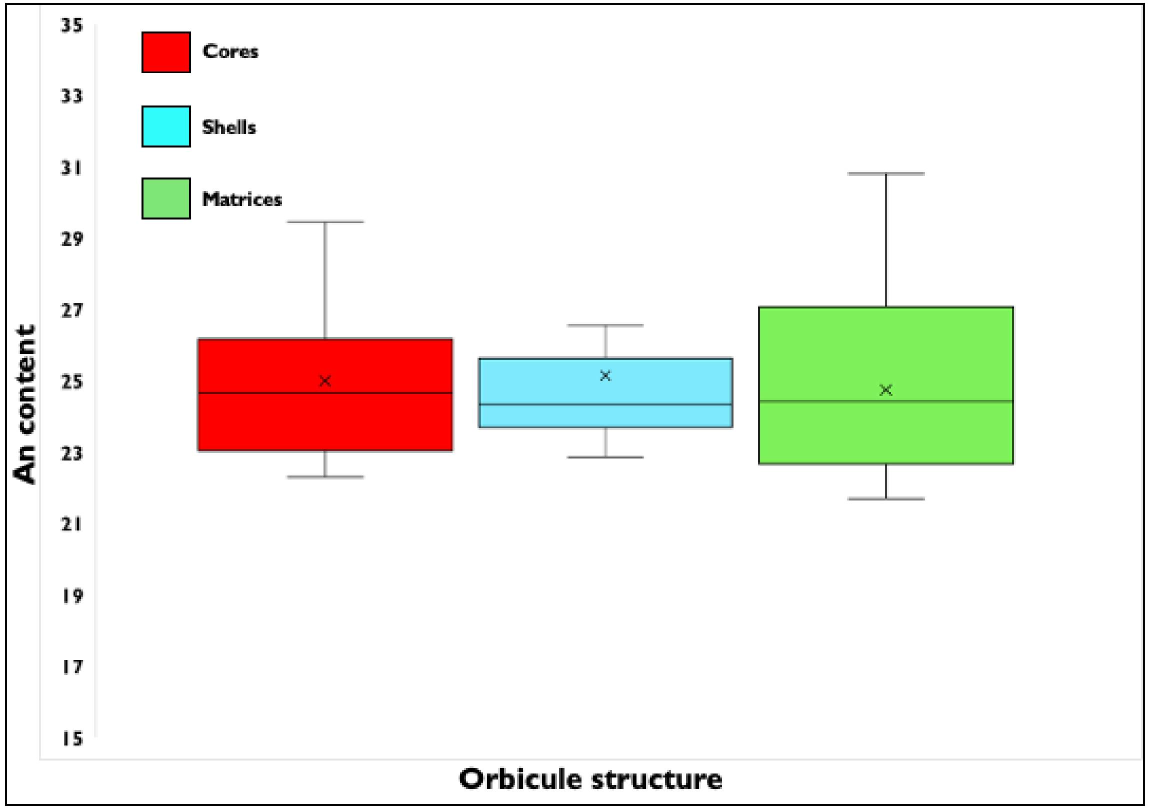


- Plagioclase analysed in core, shells and matrix. All the same composition $An_{15\text{-}32}$
- Oligoclase in composition

Mineral chemistry

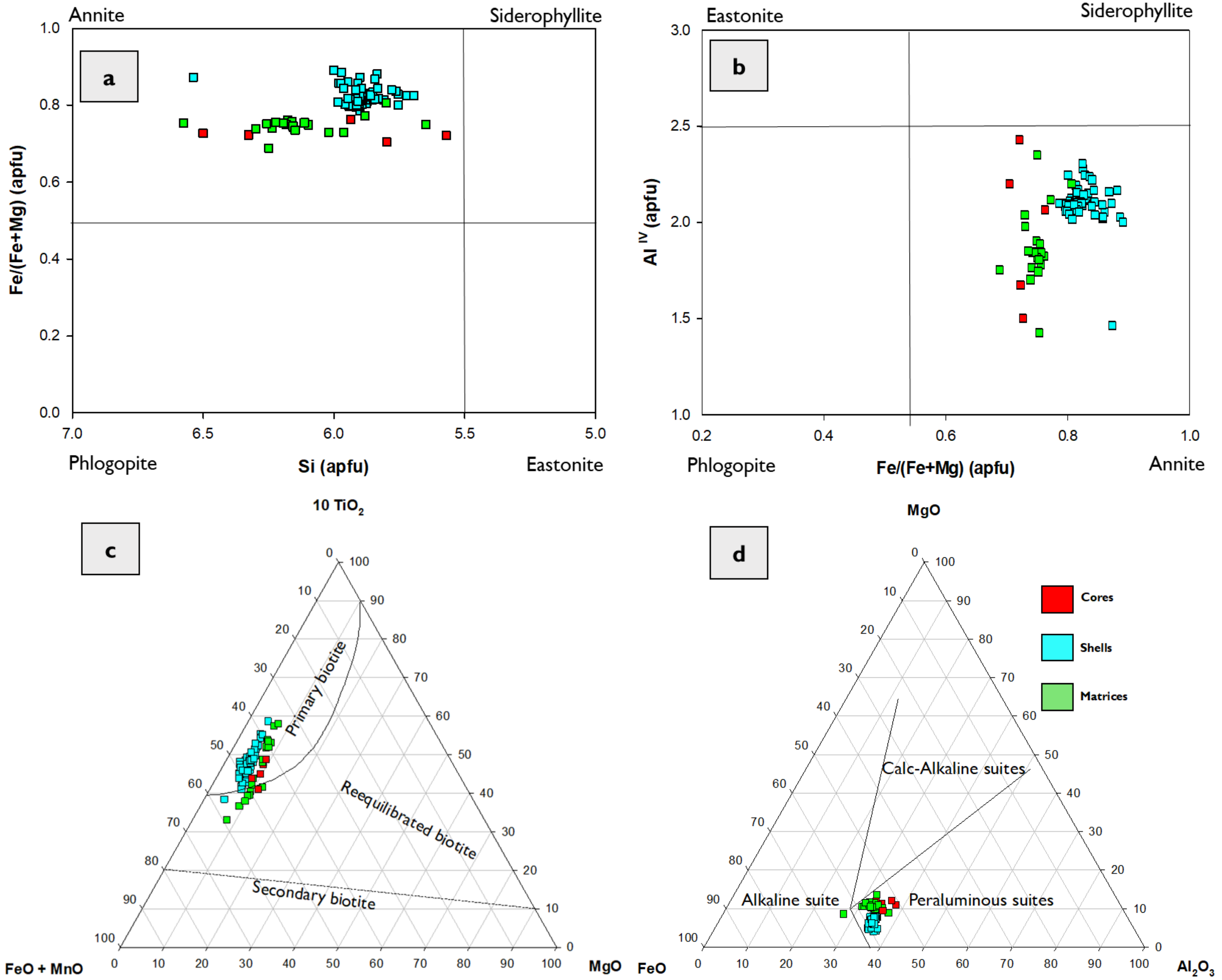
Plagioclase





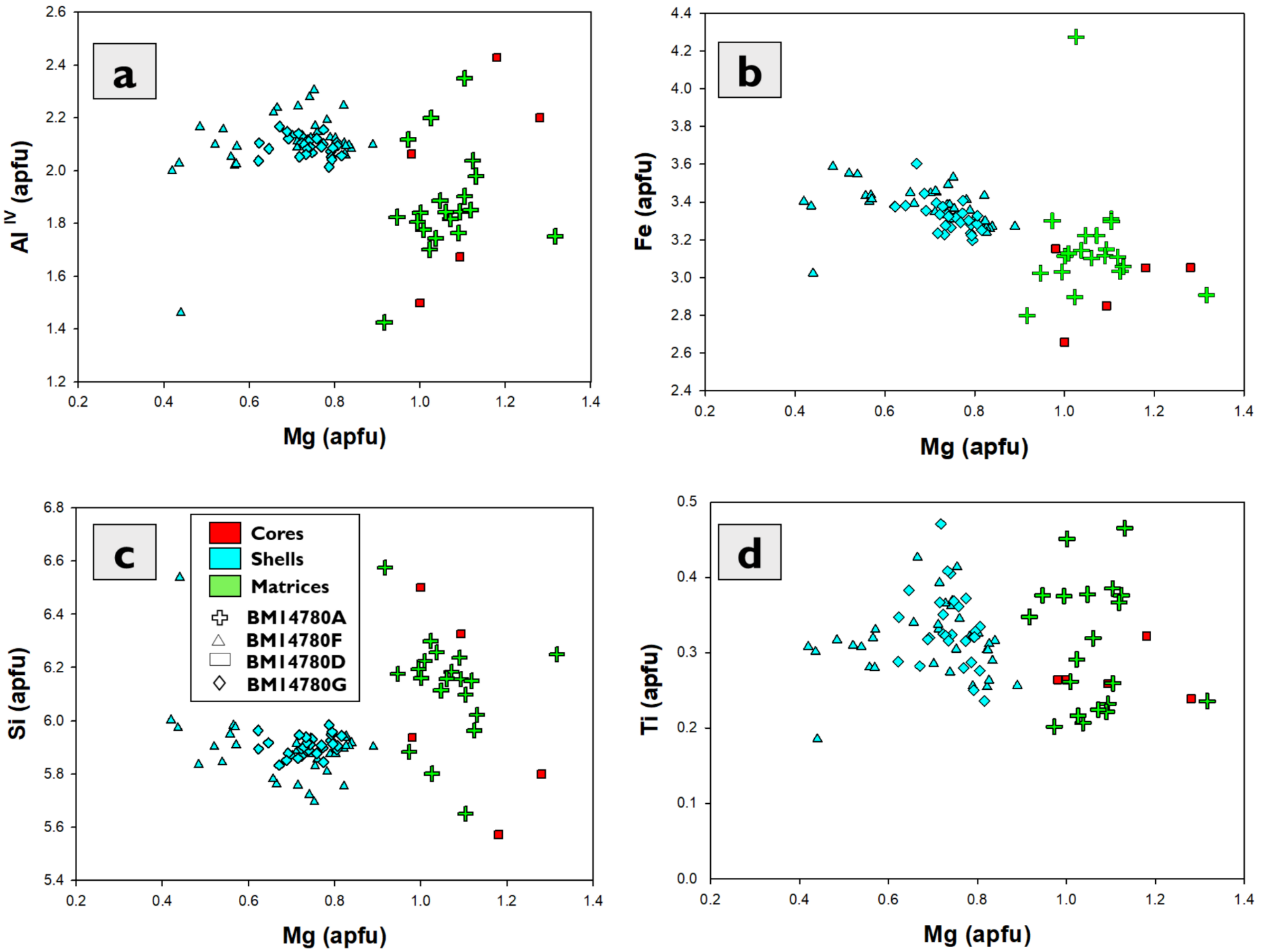
- No variation in An contents
- Plagioclase shows an almost complete overlap of An contents in cores, shells and matrix
- Average An= 26 ± 2.3 (core), = 24 ± 0.9 (shell), and 25 ± 2.0 (matrix).

Biotite Compositions



- Biotite in cores, shells and matrix all plot in the annite field
- All biotites are considered primary magmatic
- Plot in the peraluminous (S-type) granite Suite

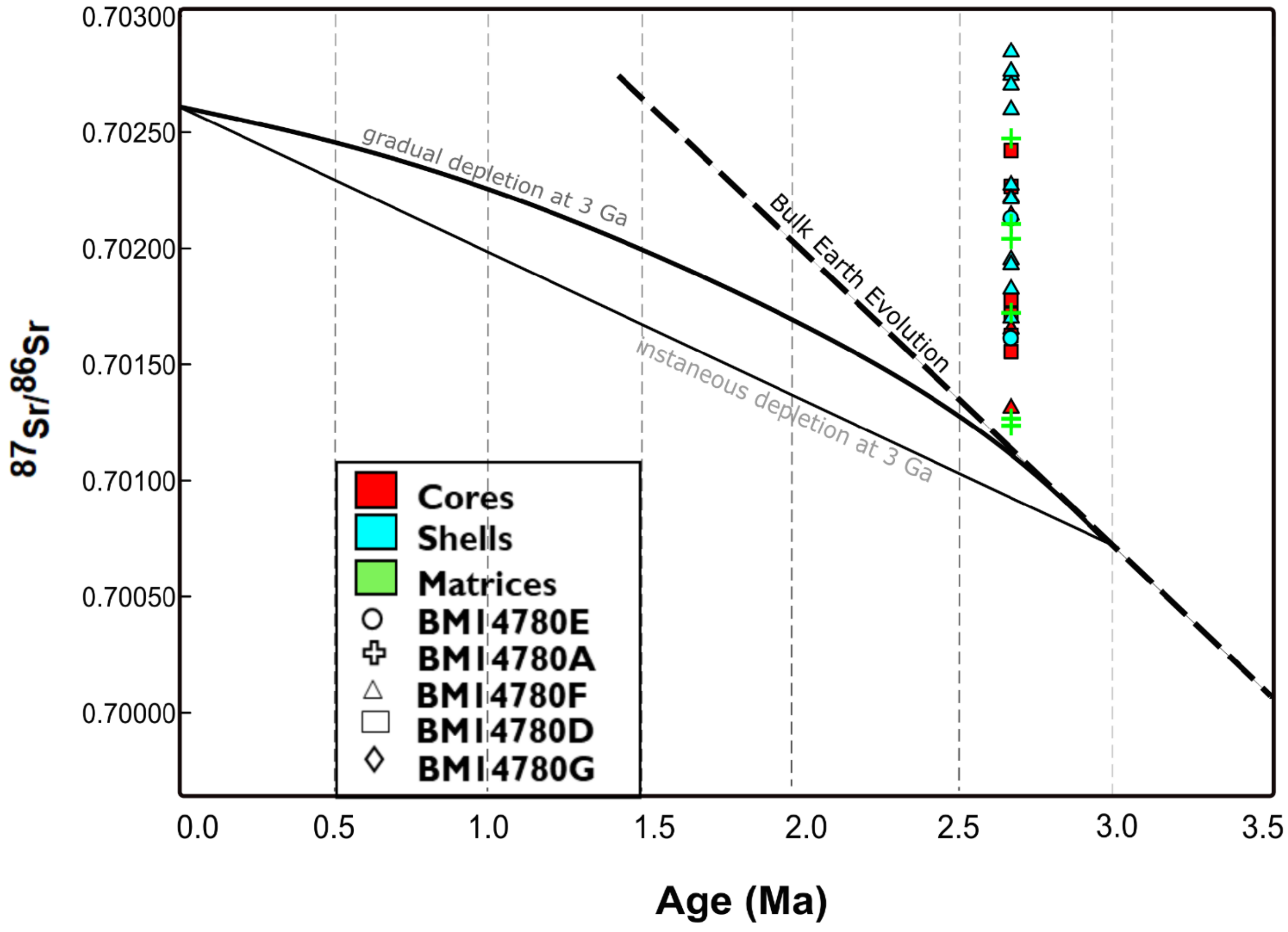
Biotite Compositions



- Biotite composition in the shells is significantly less magnesian
- Shells: (Average Mg# = 16 ± 2.4) than in
- Core: (Average Mg# = 27 ± 2.2) and
- Matrix (Average Mg# = 25 ± 2.2).

Initial $^{87}Sr/^{86}Sr$ compositions

- Initial ratios calculated using the estimated age of the Matopos Granite of (2.65 Ga)
- Plagioclase was analysed in different samples
- Plagioclase in cores and shells generally have slightly more radiogenic (higher) initial $^{87}Sr/^{86}Sr$ than in the matrix.
- Suggests a greater amount of crustal material in cores and shells. (Conversely less crustal material in the matrix).



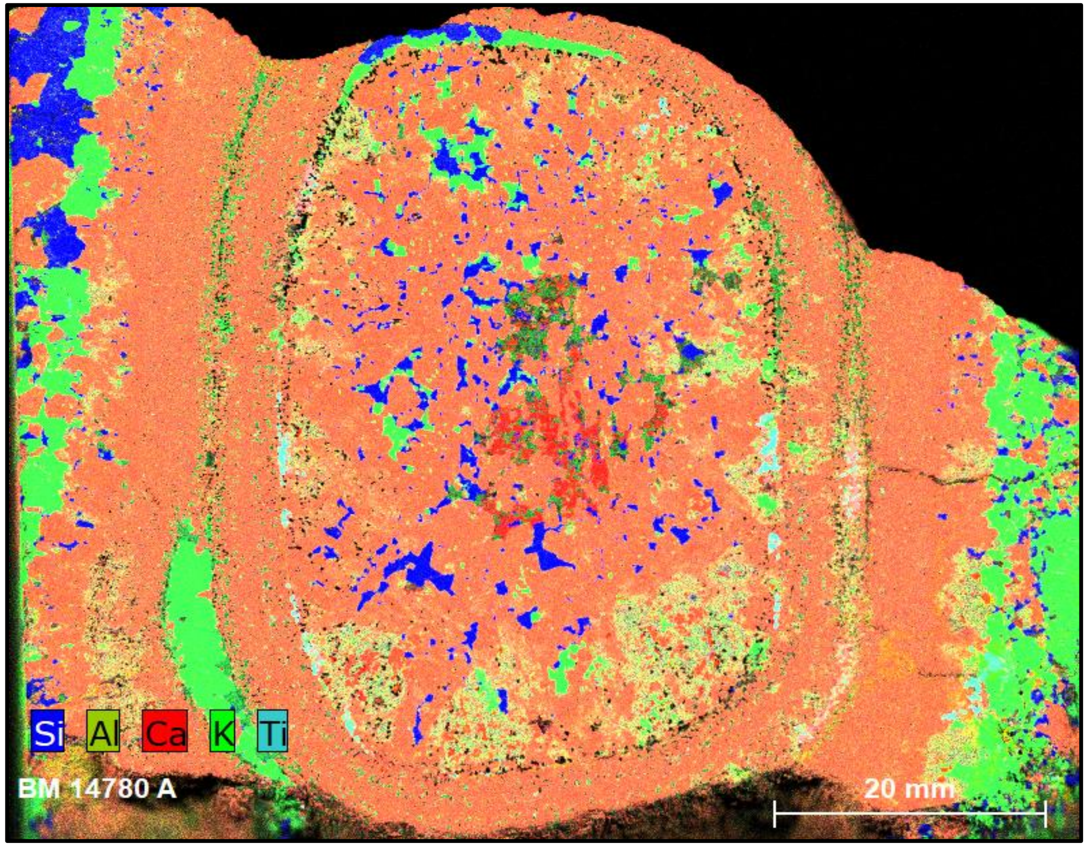
Discussion: A Magmatic vs Metasomatic Origin

- Previously attributed to metasomatic processes
- Comparable mineralogy (cores, shells and matrix)= No reaction between them
- Uniformity of mineral assemblages and Sr isotopes suggests close relationship (magmatic)
- Orbicules exhibit features indicative of transport from a deeper source as they are commonly fractured and/or deformed
- Radiating textures in shells
- Sharp contacts are not due to *in-situ* processes

Rule out the metasomatic origin

Discussion: Petrogenesis

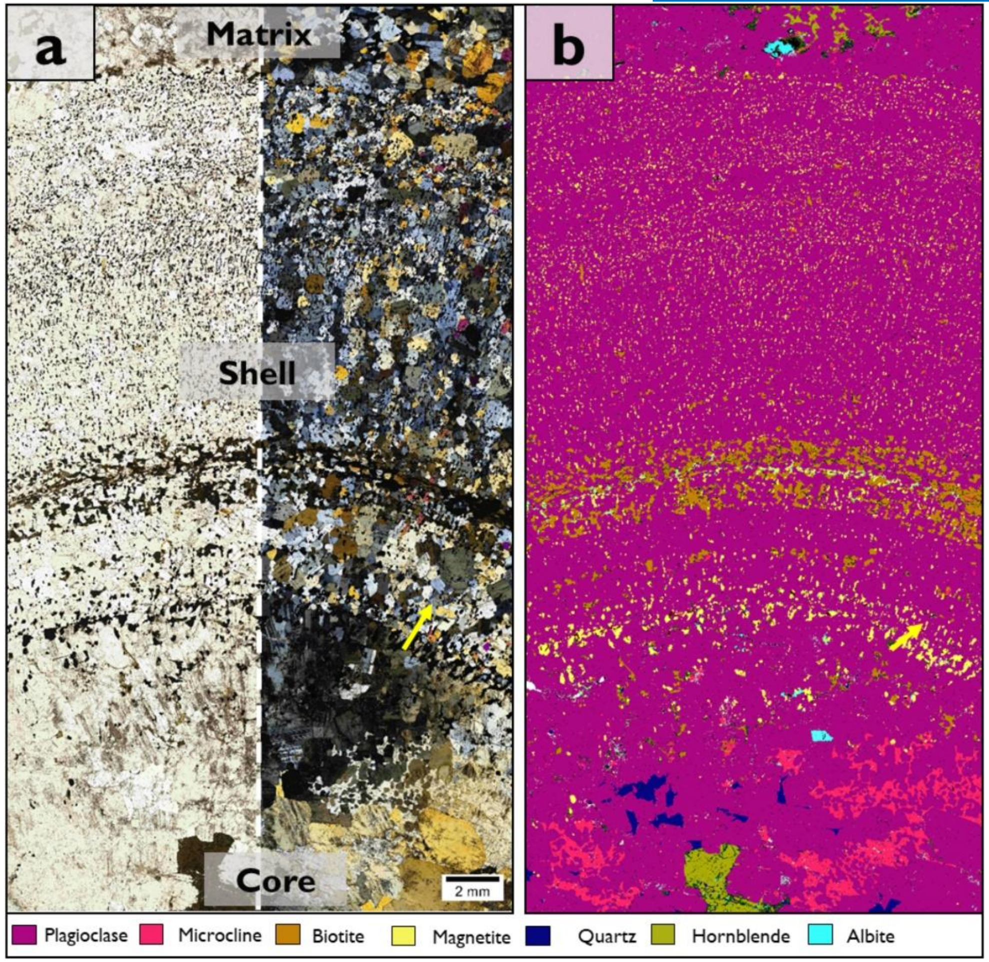
- Core Formation?



- Cores comprise subhedral to euhedral plagioclase grains that form aggregates and exhibit An contents that show an almost complete overlap with An of plagioclase in shells and the granitic matrix

- They are most likely autoliths, which are plagioclase-rich cumulates, or rim fragments reworked by new magma inputs or injections

Discussion: Petrogenesis



Formation of shells?

- Distinct from cores and matrix
- Different mineral assemblages (dominated by magnetite and biotite, and hornblende) and chemistry (less magnesian than cores and shells)
- Different textures (fine-grained and exhibit polygonal textures)
- Precludes their direct crystallization from the magma from which the cores and matrix crystallises
- Different processes at play

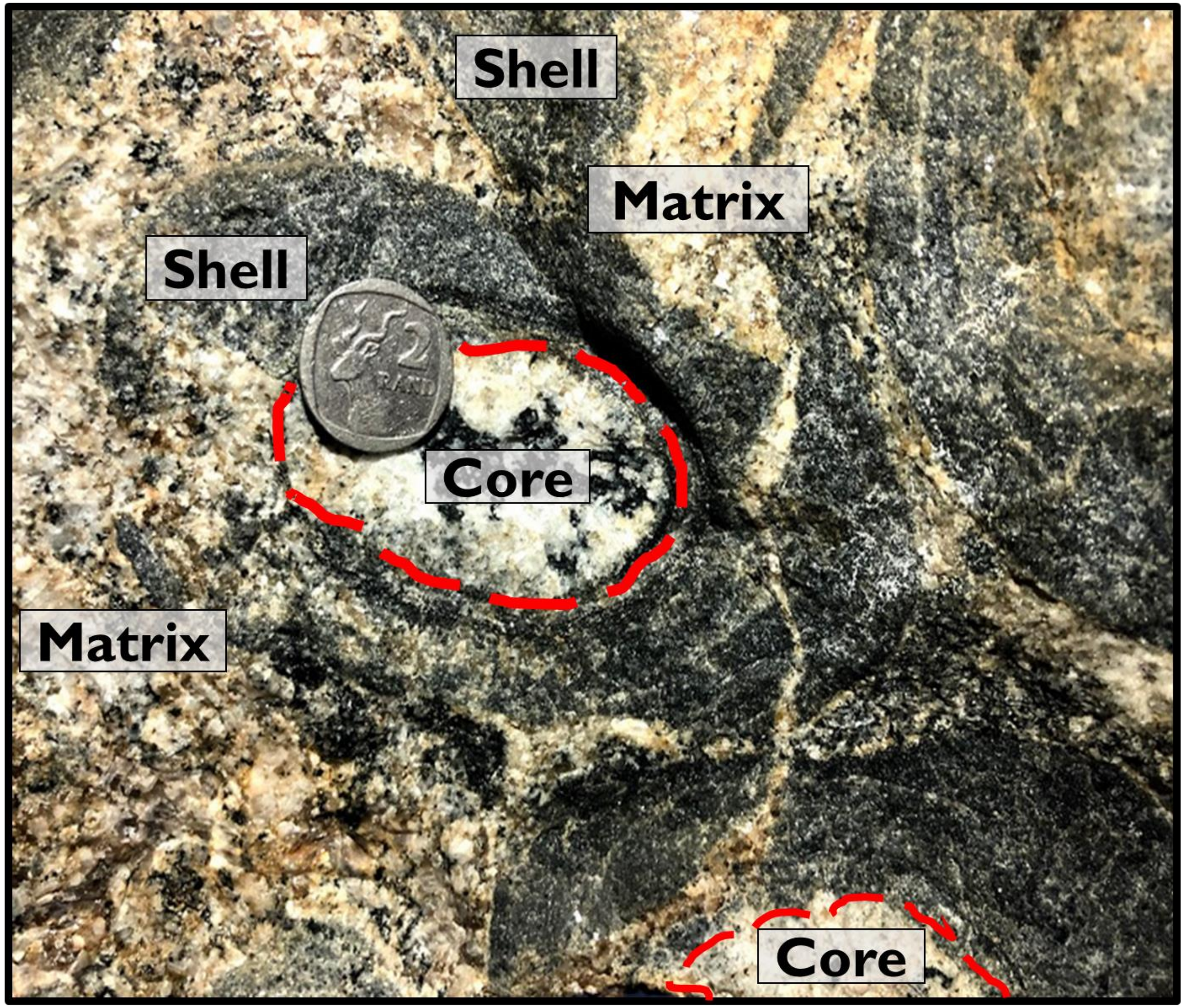
- Superheating and resorption of previous nuclei followed by undercooling and heterogeneous nucleation
- 3 mechanisms invoked:
  - Water addition
  - Introduction of hot mafic magma and magma mingling
  - Adiabatic decompression upon magma ascent (variations in pressure during decompression play a crucial role in the stability of mineral) and followed by oscillatory crystallization and supersaturation (caused by volatile exsolution upon decompression).

Discussion: Matrix formation

- **Matrix Formation?**

- Comparable compositions to cores
- More K present – slightly more evolved
- Coarse-grained

- Deforms / cross-cuts, cores and shells
- Fully crystalline and solidified at a later stage, carried the orbicules to their present setting



Thank you

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