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A Siderian Snowball Earth?

Multiscale and interdisciplinary analyses of the Makganyene Formation, South Africa

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This presentation participates in OSPP

EGU

Outstanding Student & PhD candidate Presentation contest

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I Introduction

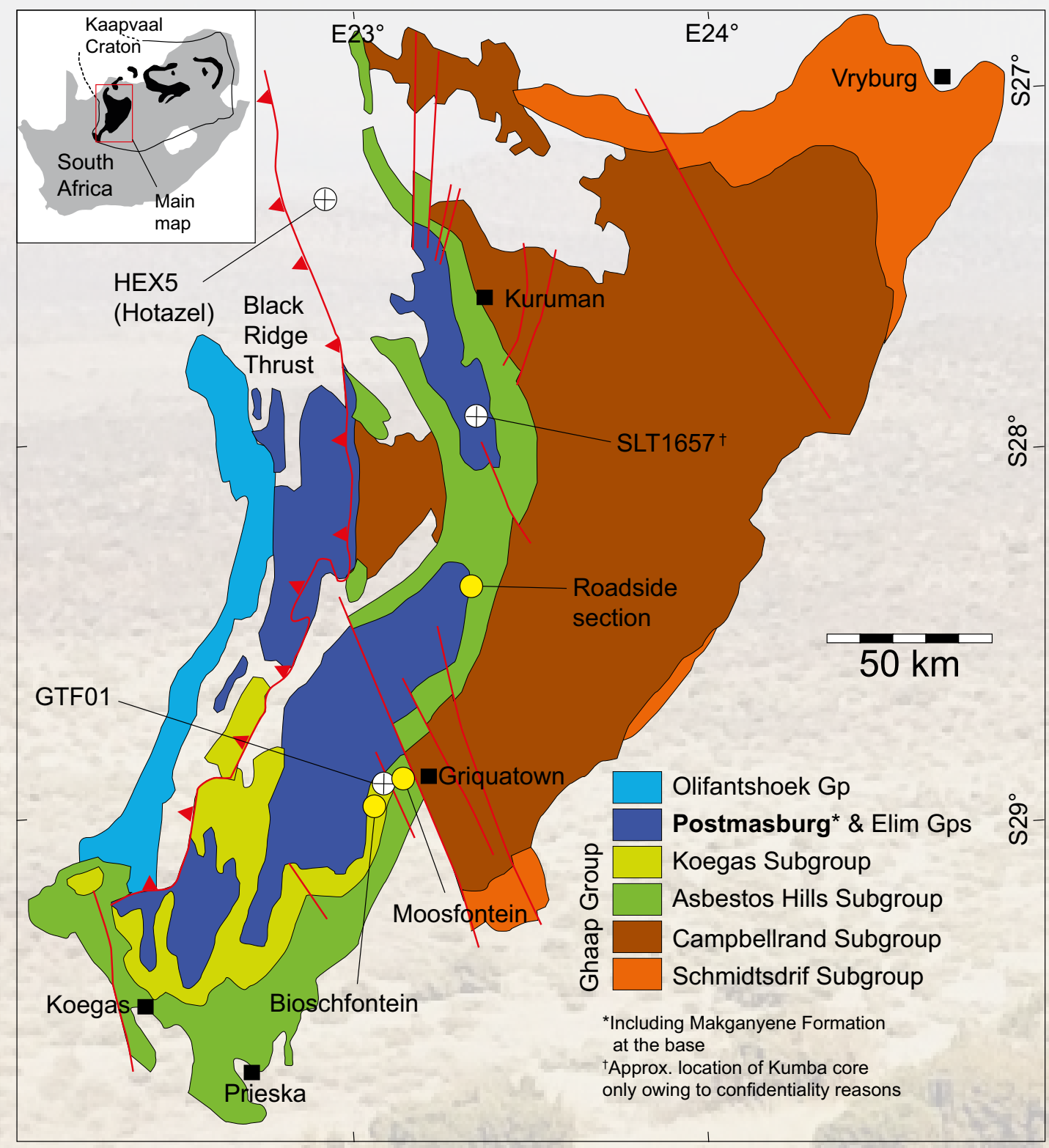

Figure 1: Geological sketch map of the Griqualand West sub basin of the Transvaal Supergroup (redrawn after Schröder et al., 2011) including the location of outcrops visited and boreholes examined in this study.

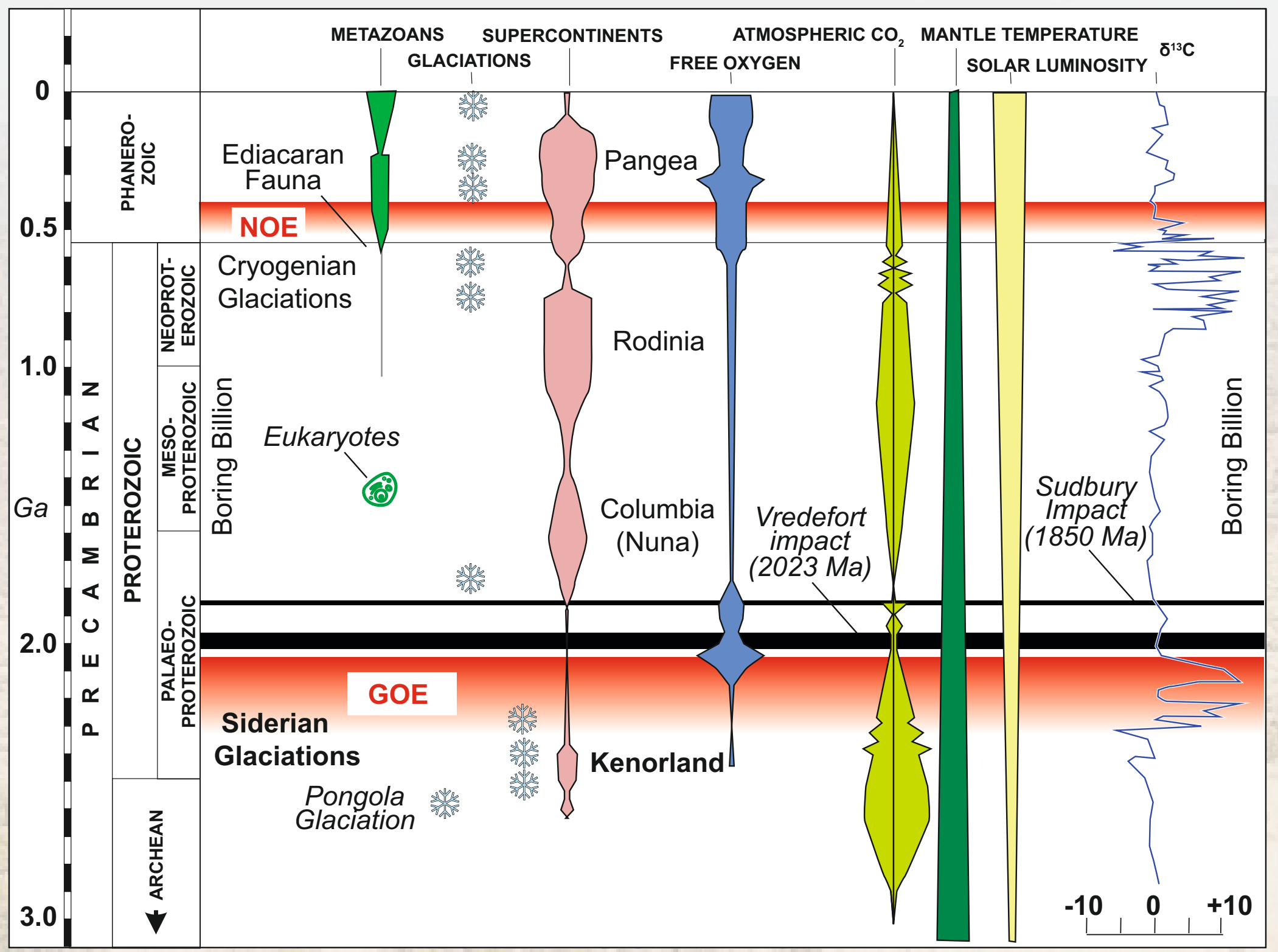

Figure 2: Timeline of events throughout the Proterozoic, including the Siderian glaciations of the Palaeoproterozoic. Redrawn and slightly modified from Young (2013).

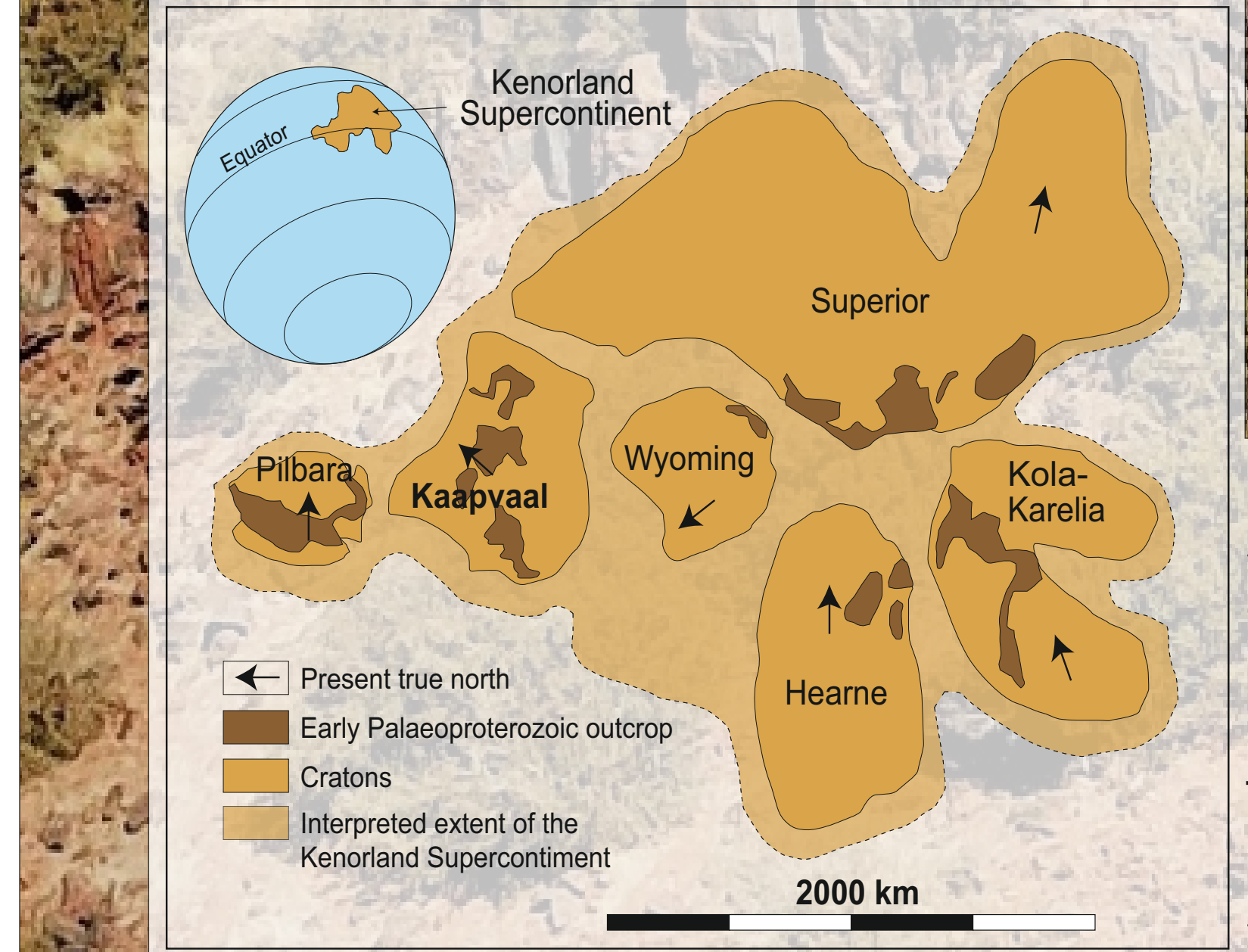

Figure 3: Palaeoproterozoic craton configuration and palaeogeography, showing the location of the Kaapvaal Craton in the supercraton Vaalbara configuration within the proposed supercontinent of Kenorland. Available paleomagnetic data indicate that the bulk of the cratonic fragments has positioned at low latitudes. Glacial units, recorded at each cratonic fragment, are overlain by dolerite dikes and sills of large igneous provinces (LIPs) emplaced between ca 2.51 and 2.43 Ga. Redrawn and simplified after Gumsley et al. (2017).

II Multiscale Analyses

Macroscale
Outcrops & subcrops
- Sedimentological logs
- Outcrop recording
- Facies anylsis
- IF classification

Microscale
Polarizing Light Microscopy
- Micromorphology
- Microsedimentology
- Petrography

Microscale
SEM
- Micromorphology
- Element distribution mapping
- EDX mineral spectrography
- Microsedimentology

Acknowledgements

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References

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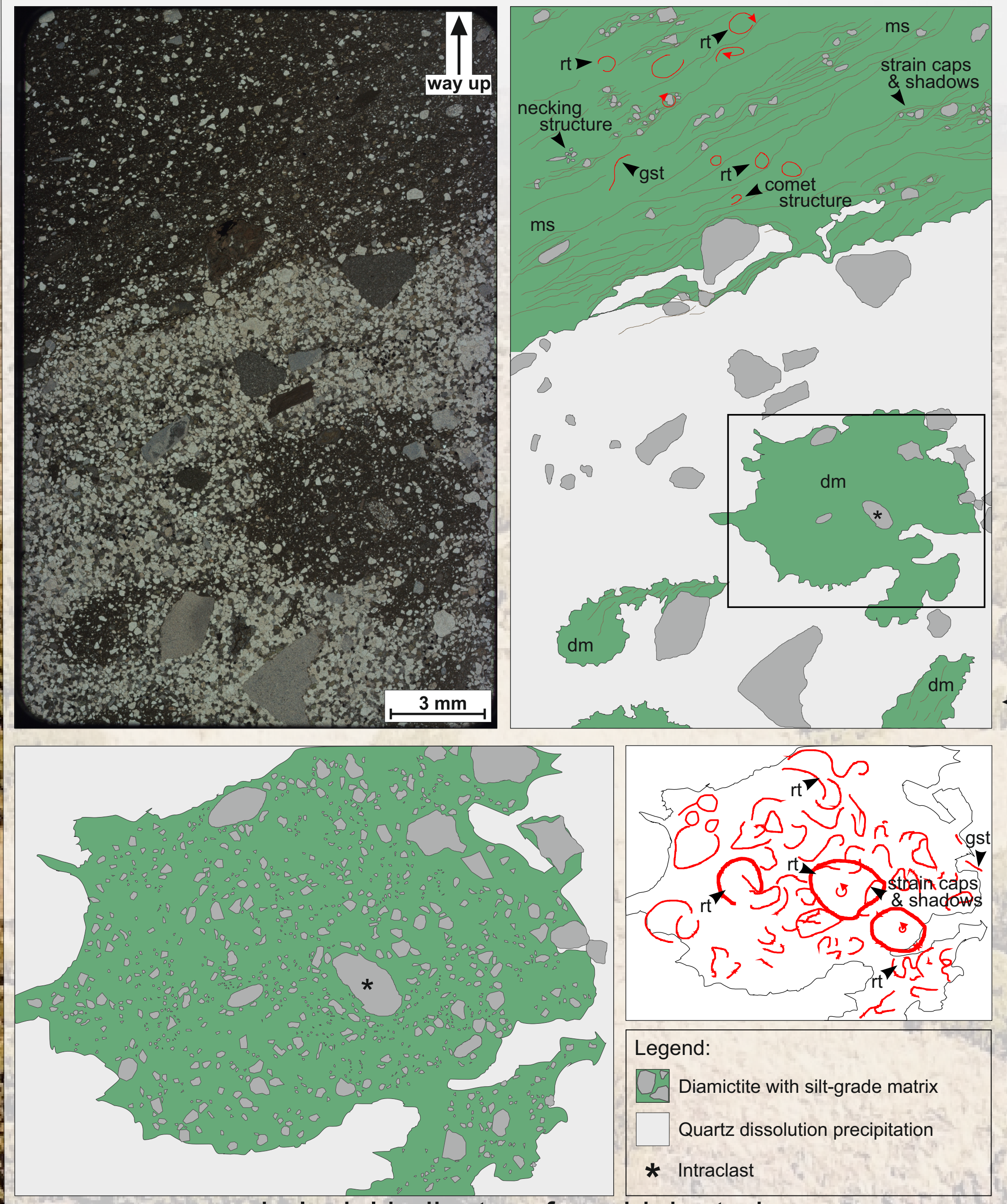
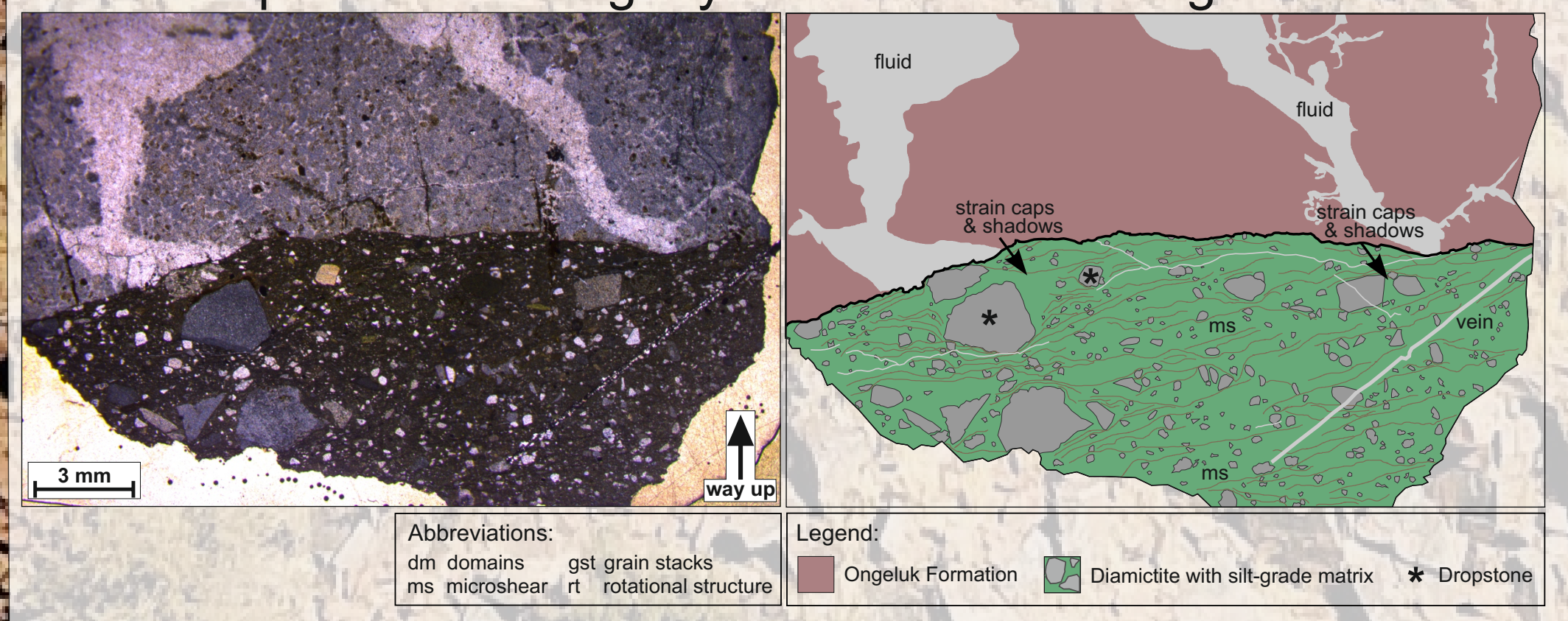
III Results & Discussion

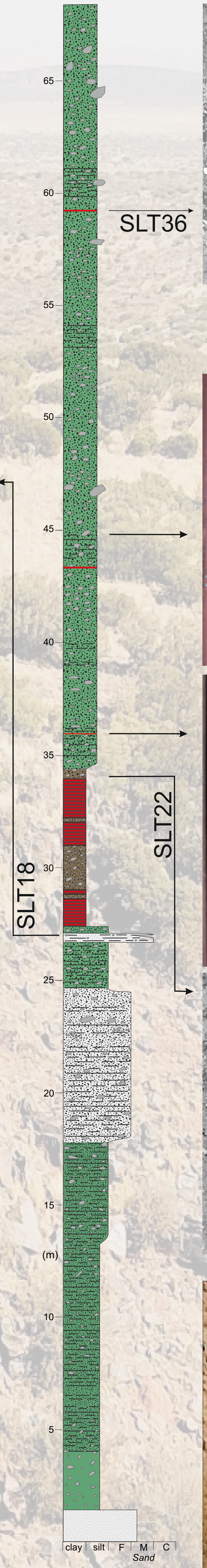


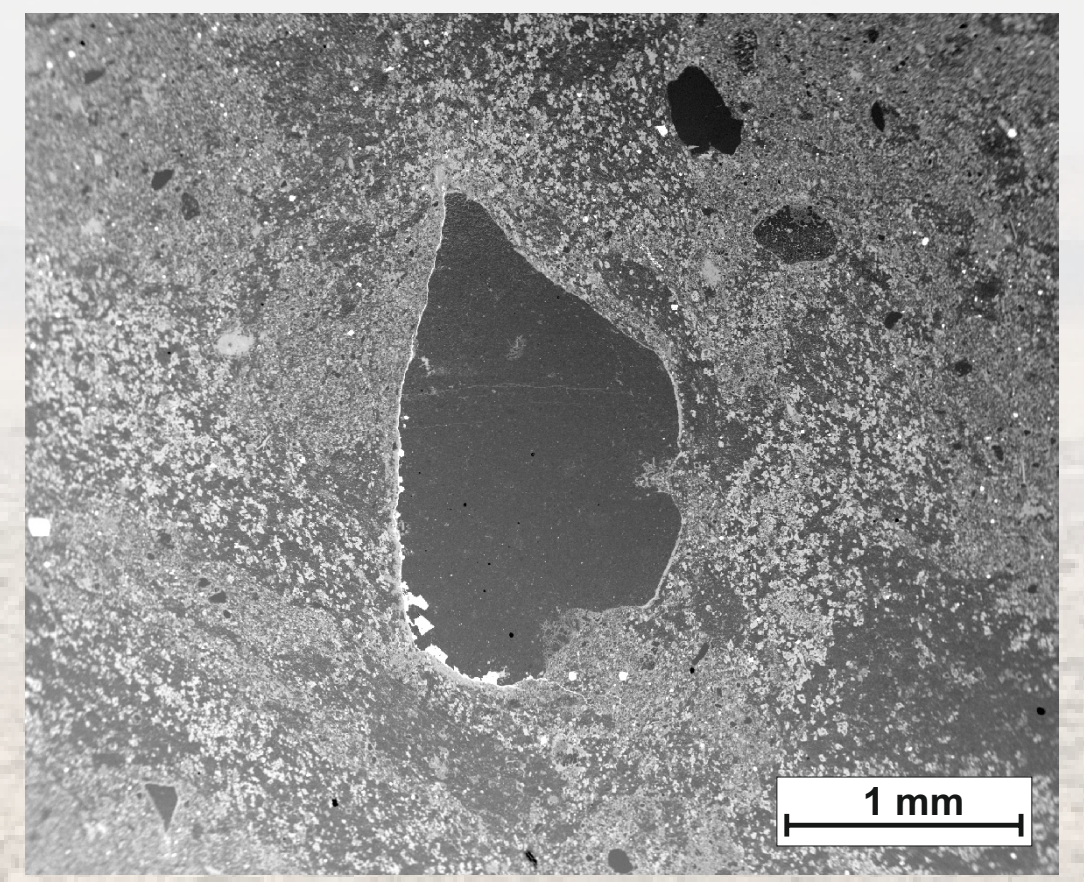
subglacial indicators for a high strain

sharp contact: Makganyene Formation / Ongeluk LIP



SLT 1657 Core

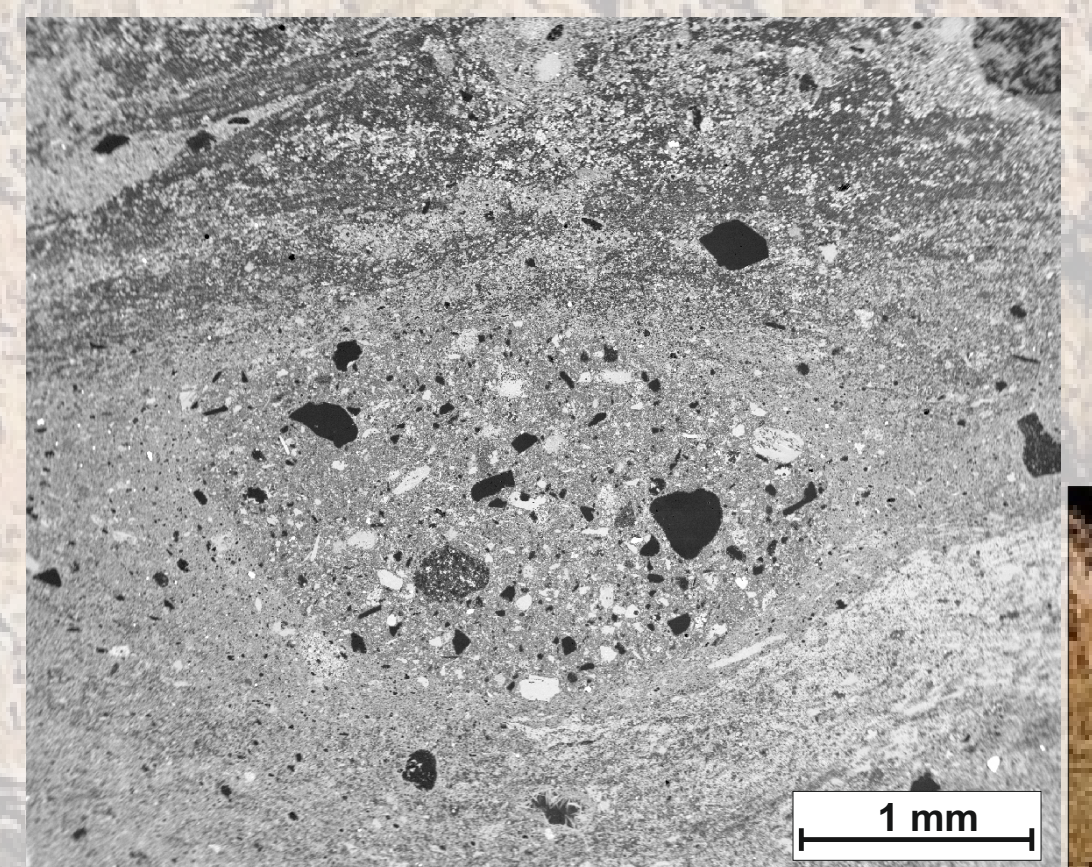




putative dropstone surrounded by Siderite $FeCO_3$ + Ankerite $Ca(Fe^{2+},Mg)(CO_3)_2$

rotational structures

Iron Formation (cm 6)



intraclast

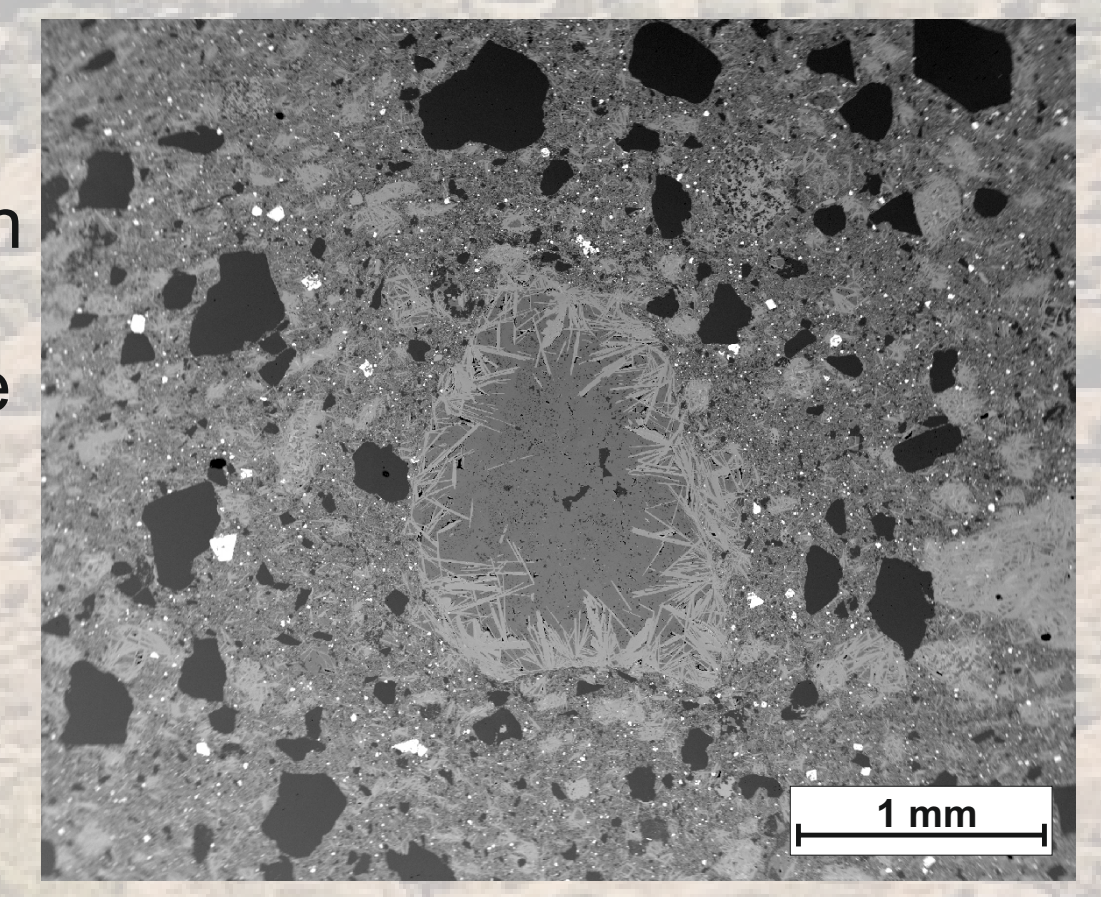
Legend (Logs):
- ▤ *Iron formation*
- ▨ *Diamictite with clay-grade matrix*
- ▨ *Diamictite with silt-grade matrix*
- ░ *Sandstone*
- ░ *Pebbly sandstone*
- *Dropstones*
- *Stratification*

HEX 5 Core

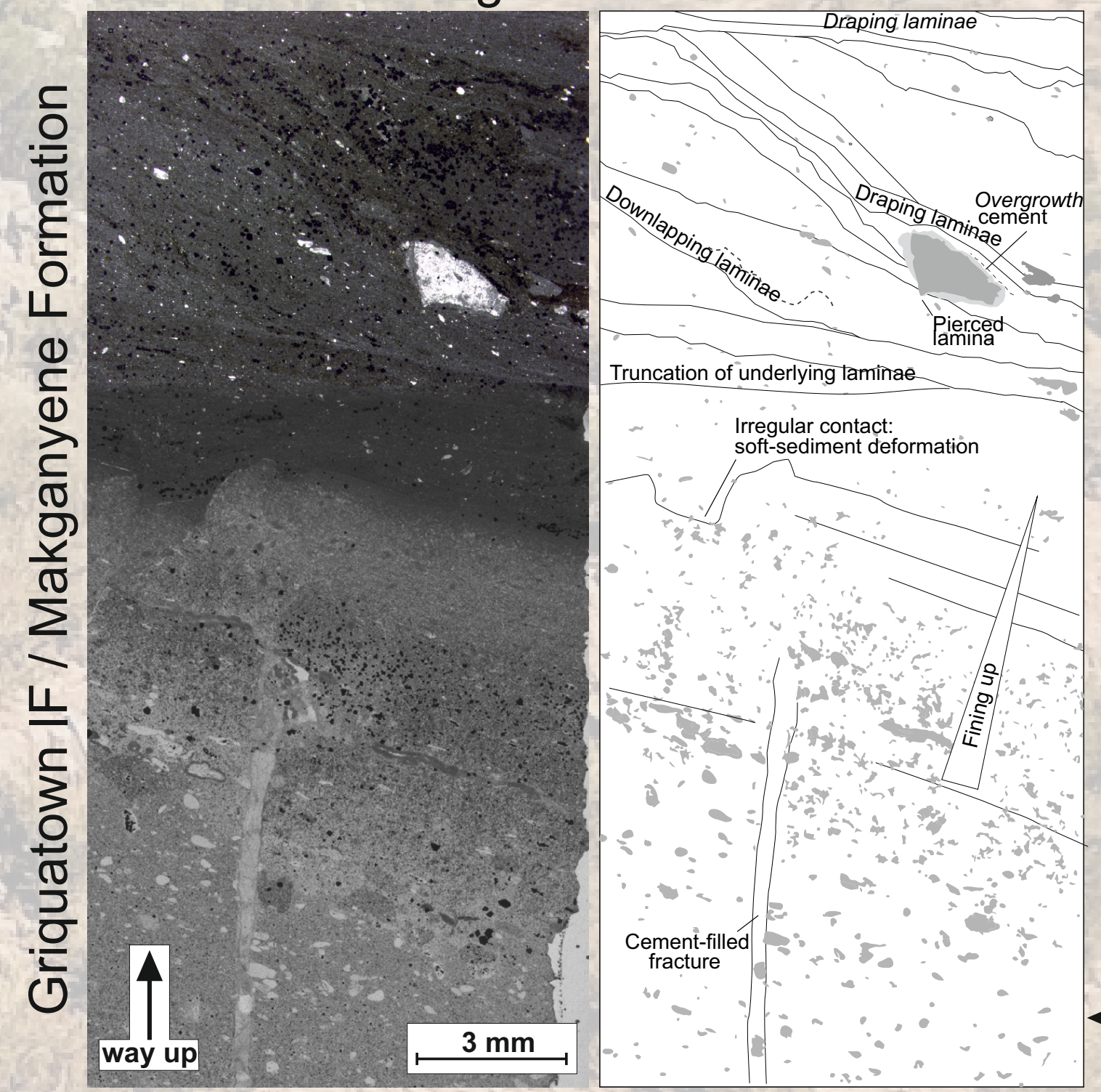
granule compaction

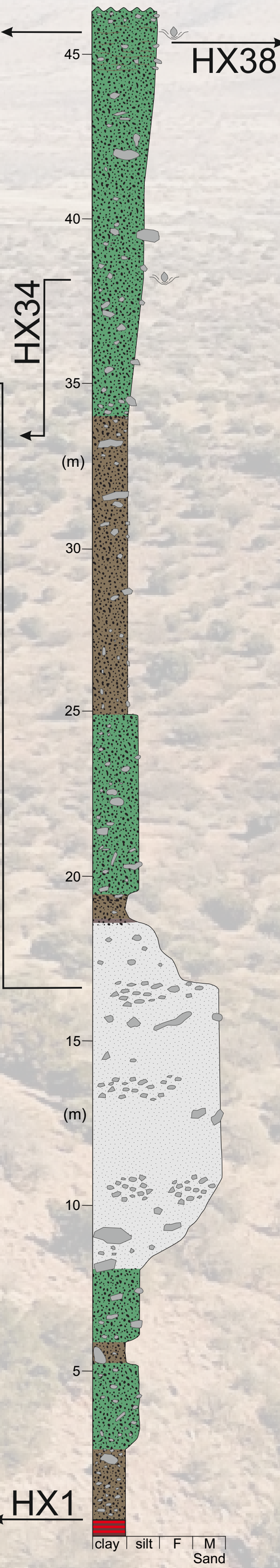
dropstone

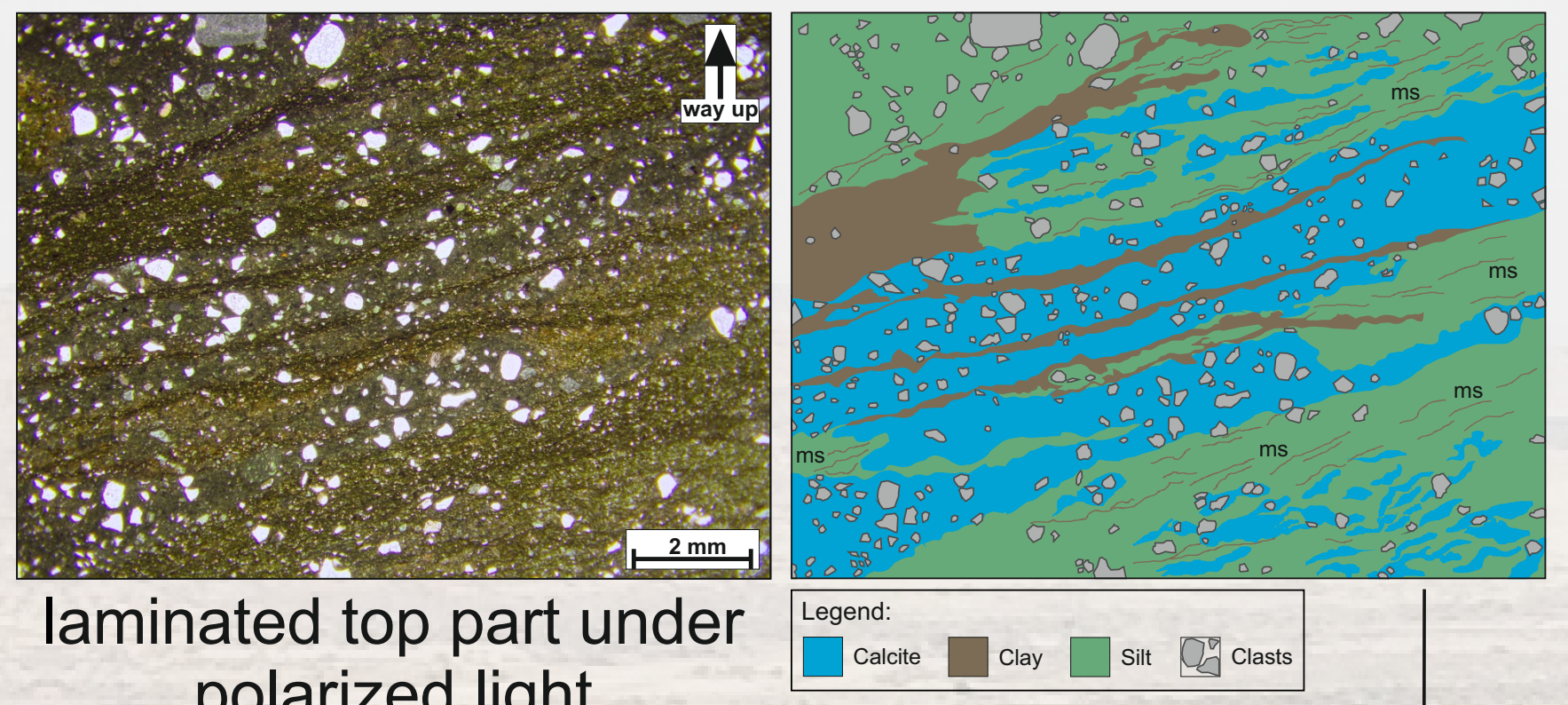
altered clast in SEM with turbate structure



irregular contact

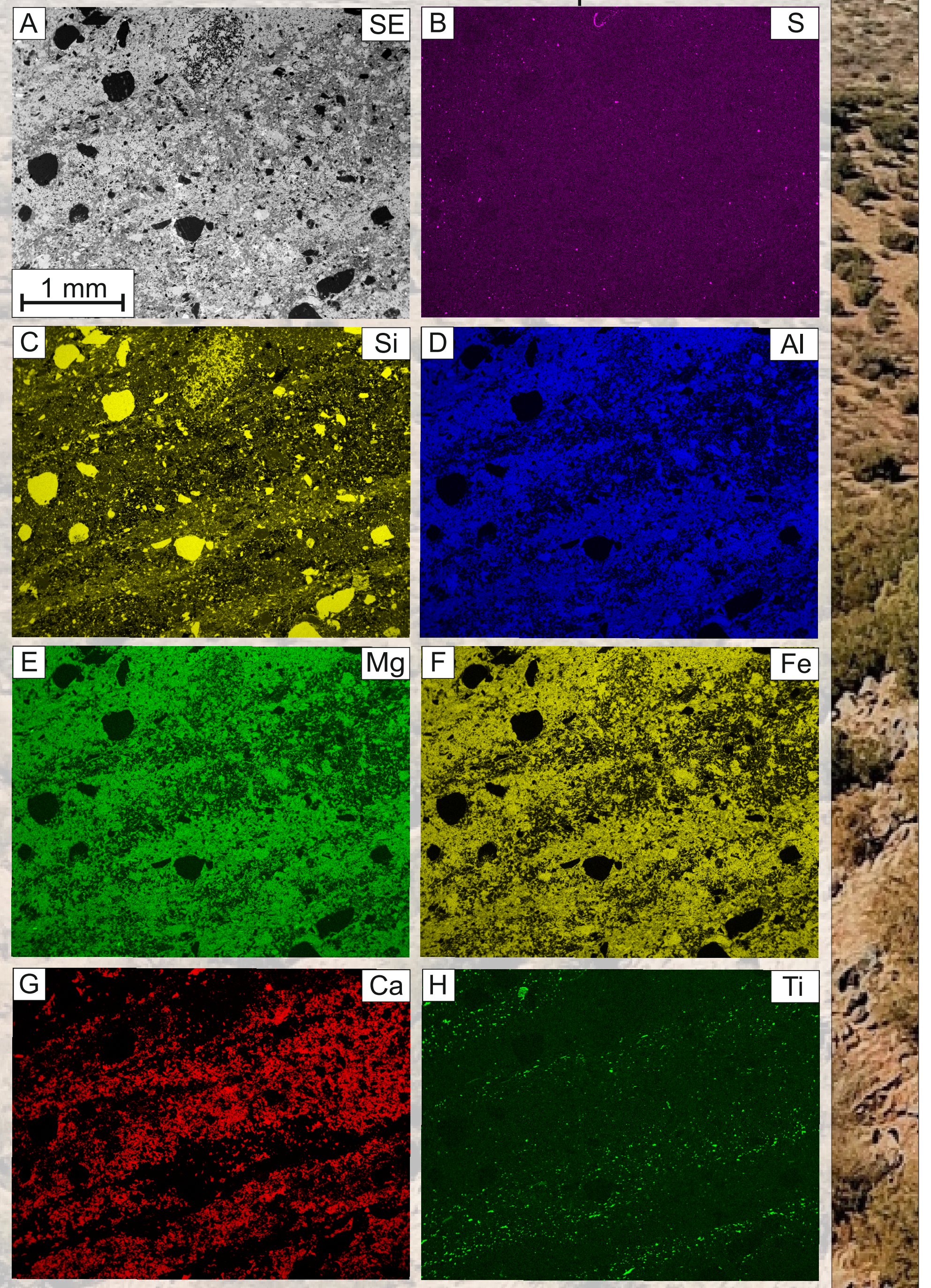






laminated top part under polarized light

Element distribution maps



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For a conceptual model explanation of a GZW check this illustration from Gohl et al., 2021.

Any Questions? Contact me!
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IV Conclusion

- Diamictite data implies the deposition of the Makganyene Formation at a grounding zone wedge (GZW).
    - At least four distinct progradational stacking patterns can be recognised and interpreted to reflect a minimum of four ice-margin fluctuations during the overall retreat.
    - Ice-rafted debris (e.g. dropstones) indicate iceberg rainout.
    - Massive diamictites and indicators for early erosion (e.g. intraclasts) indicate localised mass flow deposition.
    - The dominance of poorly sorted, highly concentrated glaciomarine deposits and the limited evidence for meltwater reworking implies the deposition by a relatively cold glacier (ice shelf setting).
- Interbedded micritic iron formations are classified as Superior-type.
- The matrix (e.g. high content of Fe-silica) and inputs of Fe-carbonates before and above IFs reflect the ferruginous ocean chemistry.