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Scientific Presentation 175

Is there a link between orogenic collapse and lithium-bearing pegmatites?

T.K. Cawood, J. Cutts, and A. Godet

2025

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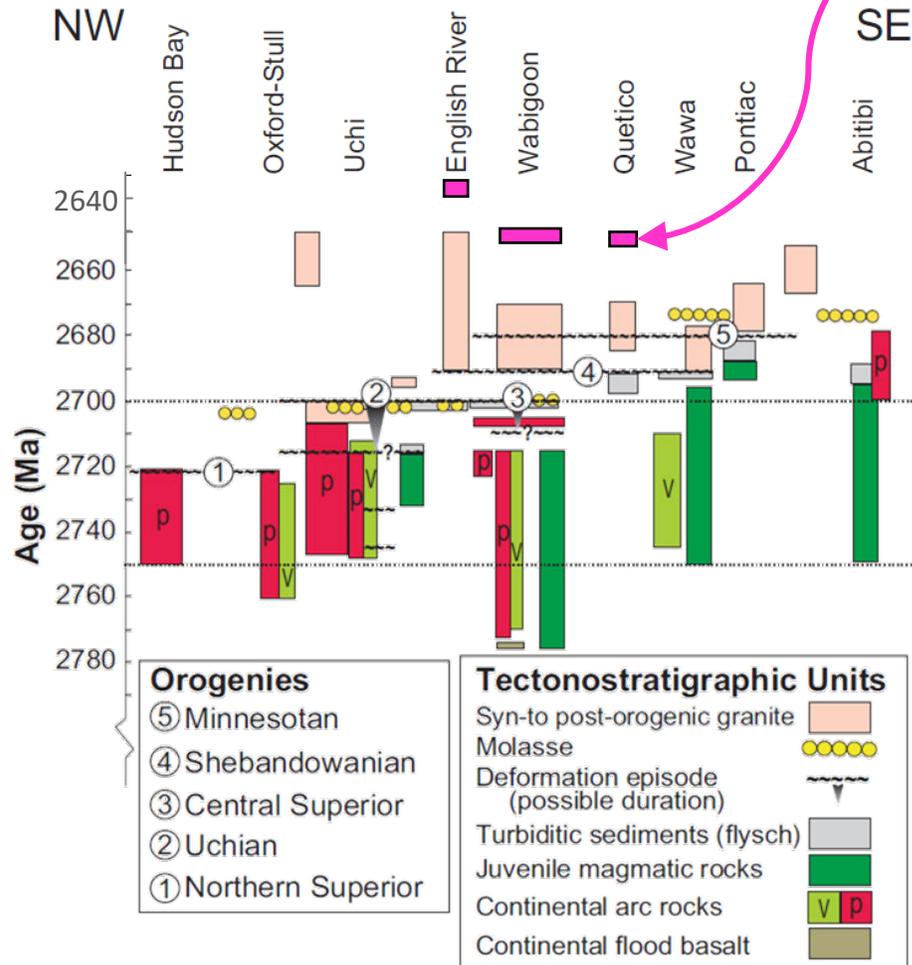


Is there a link between orogenic collapse and lithium-bearing pegmatites?



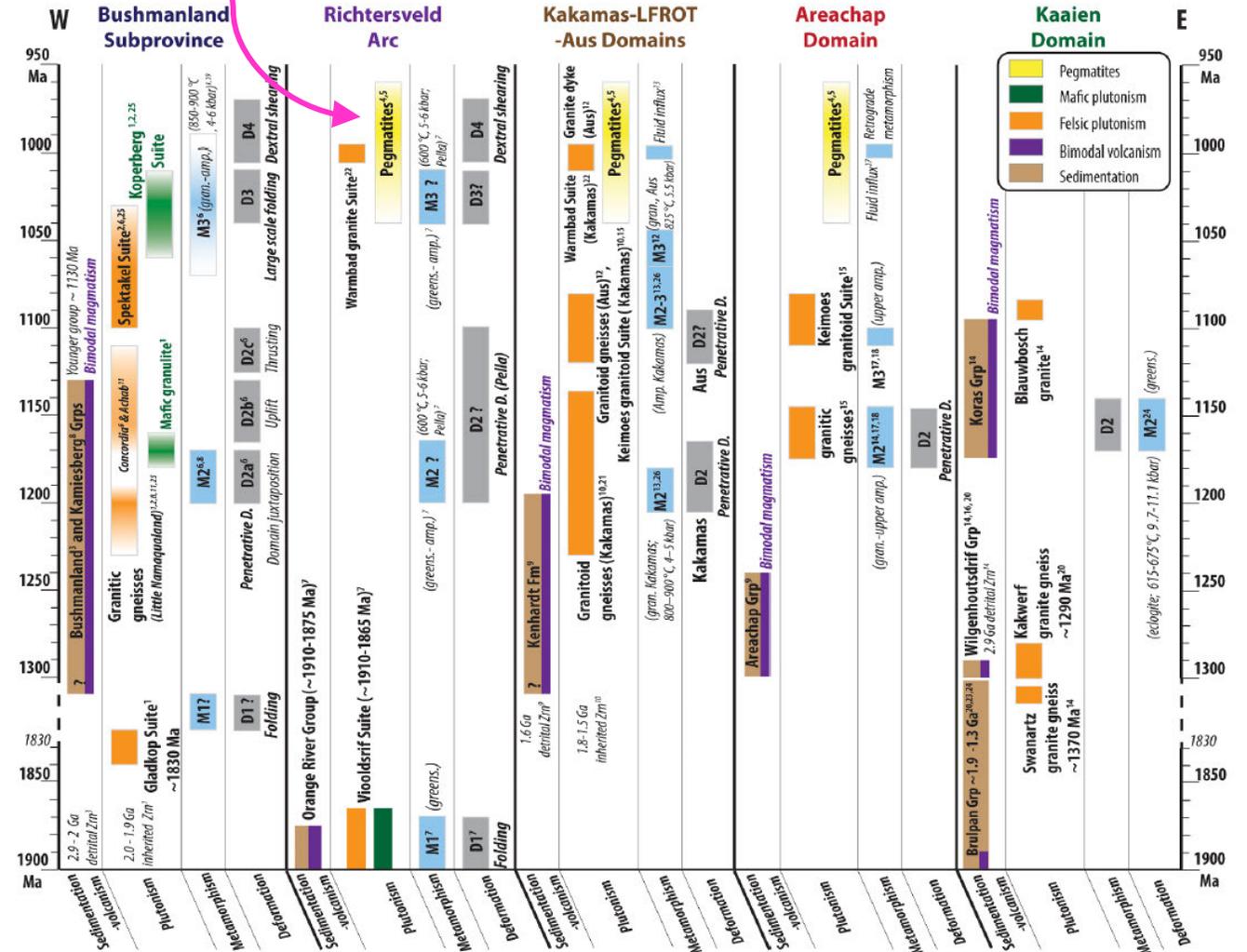
Setting the Scene

Western Superior Province, Canada:



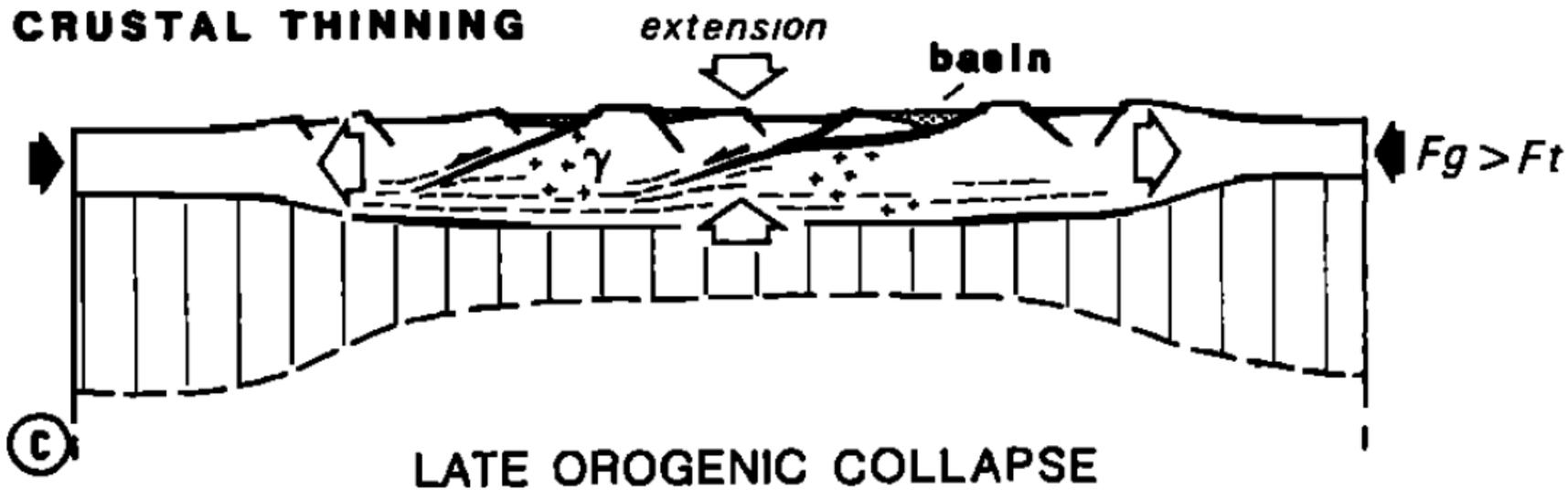
Percival et al. 2012, Geol. Assoc. of Canada Sp. Paper 49

Namaqua Metamorphic Belt, Southern Africa:



Ballouard et al. 2020, Ore Geology Reviews

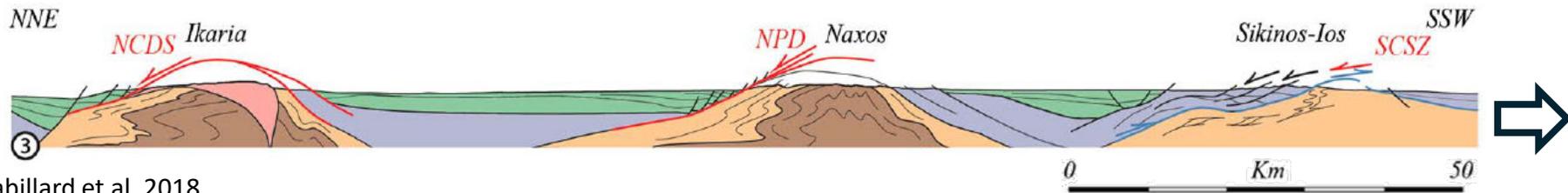
Recognizing Orogenic Collapse



Malavielle 1993, Tectonics

Potential Evidence for Orogenic Collapse:

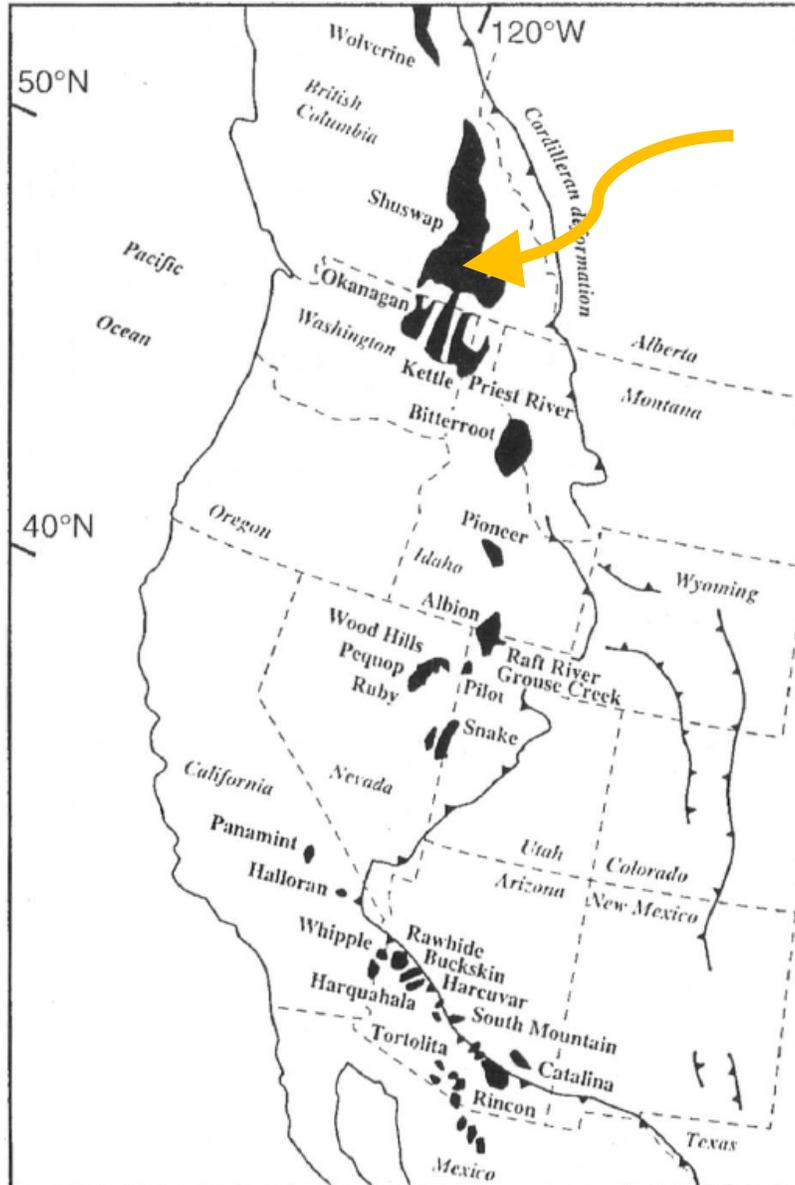
Late high-T low-P meta	✓
Thinned lithosphere	✓
Metamorphic core complexes	✓
Low-angle detachment structures	✓
Gently dipping fol ± stretching lin	✓
Steep metamorphic gradients	✓
Basins with coarse clastic sediments	✓
Shallow supracrustals preserved	✓



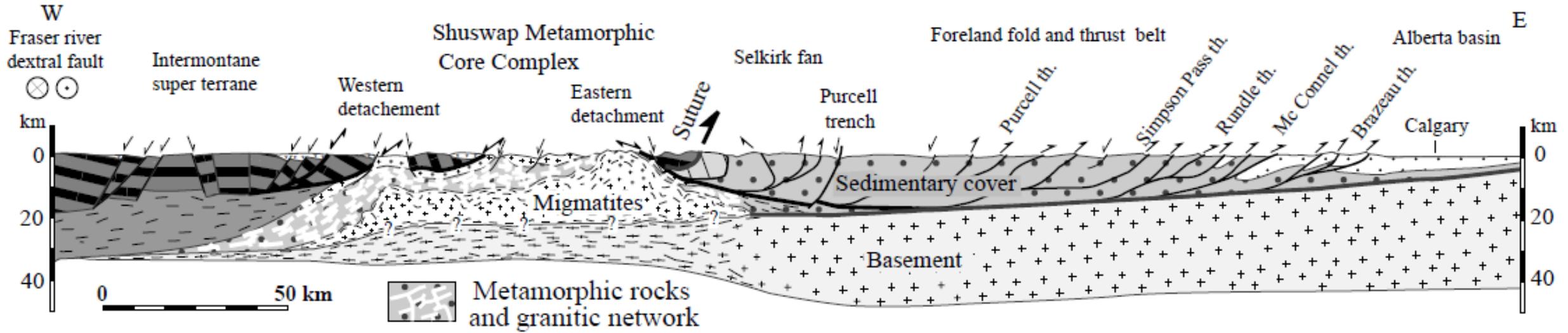
Rabillard et al. 2018,

Dewey 1988, Tectonics

#1: Li-Pegs of the Monashee Complex

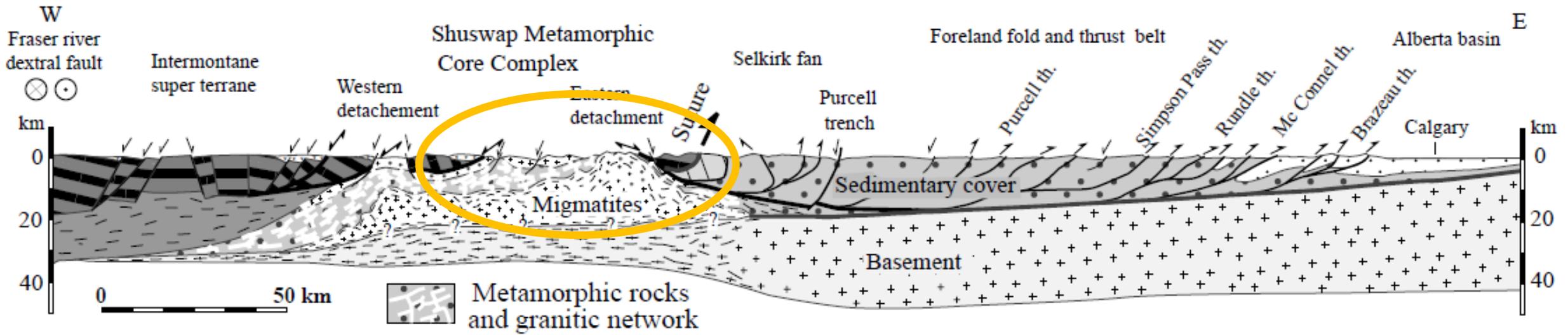


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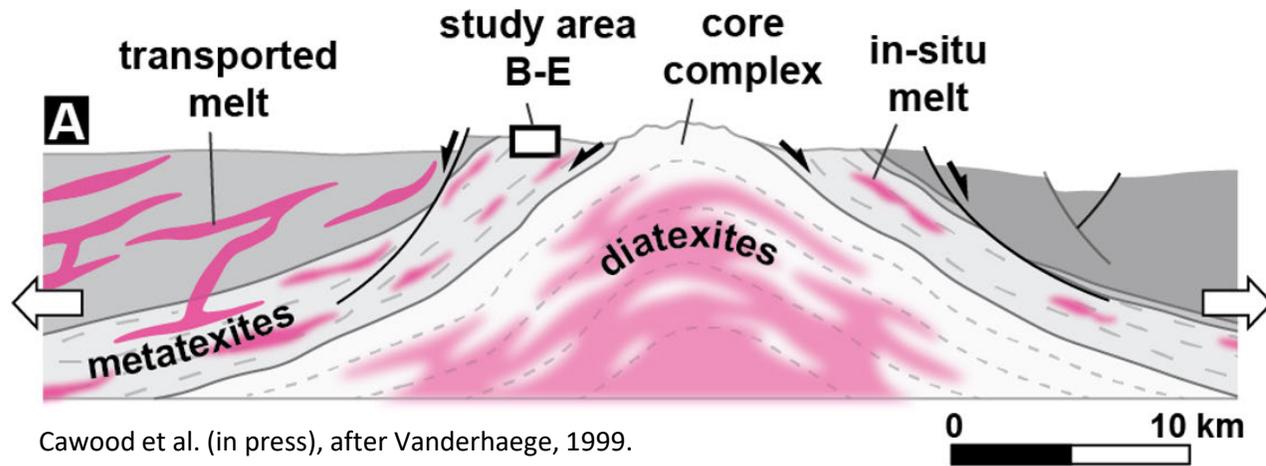


Vanderhaege, 1999, Tectonophysics

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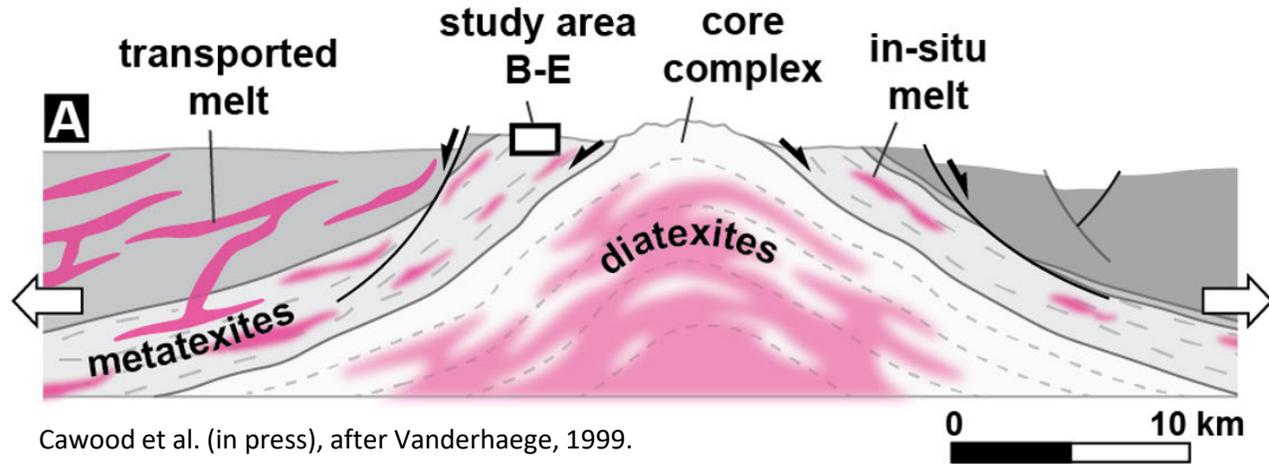
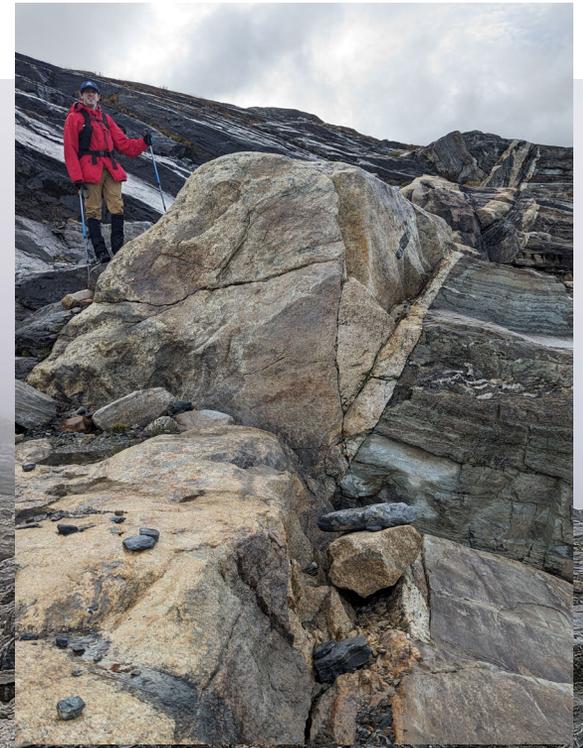


Vanderhaege, 1999, Tectonophysics



Cawood et al. (in press), after Vanderhaege, 1999.

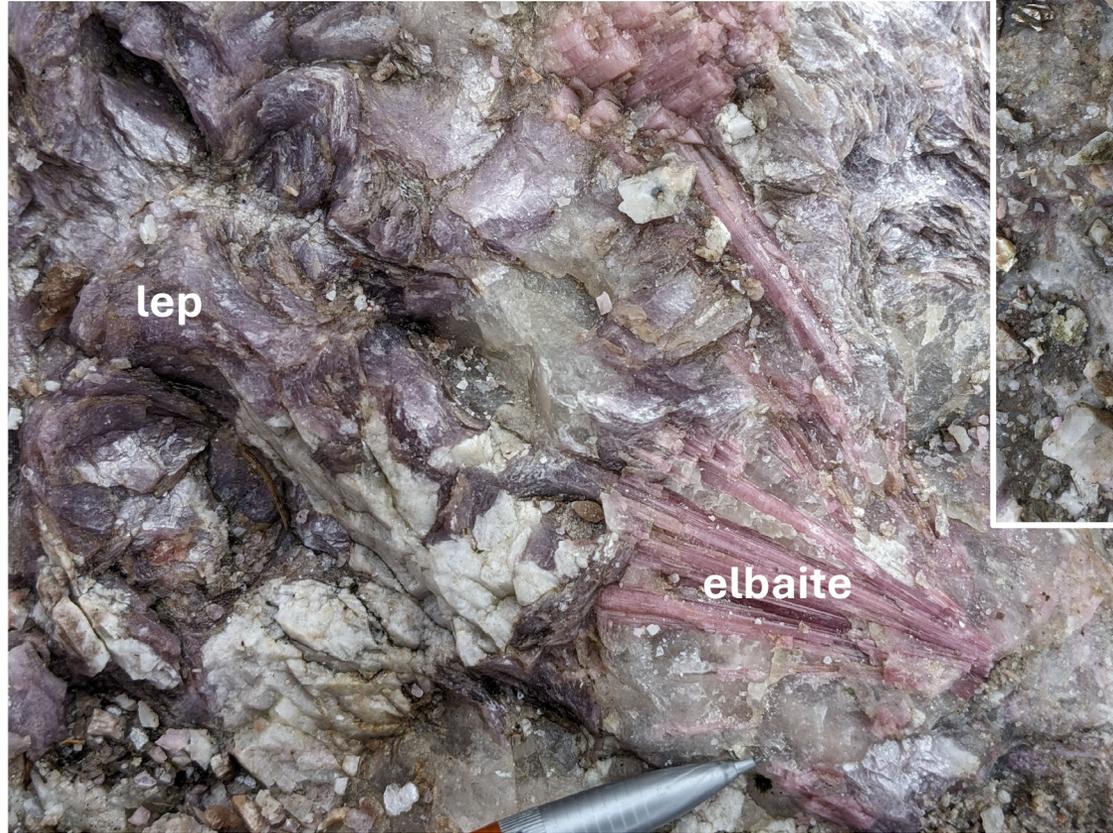
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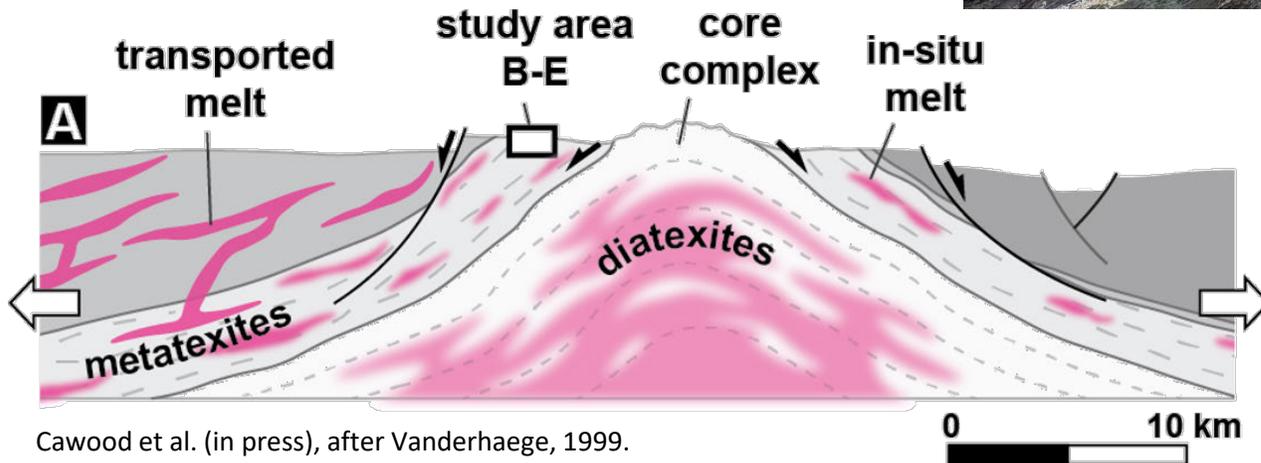
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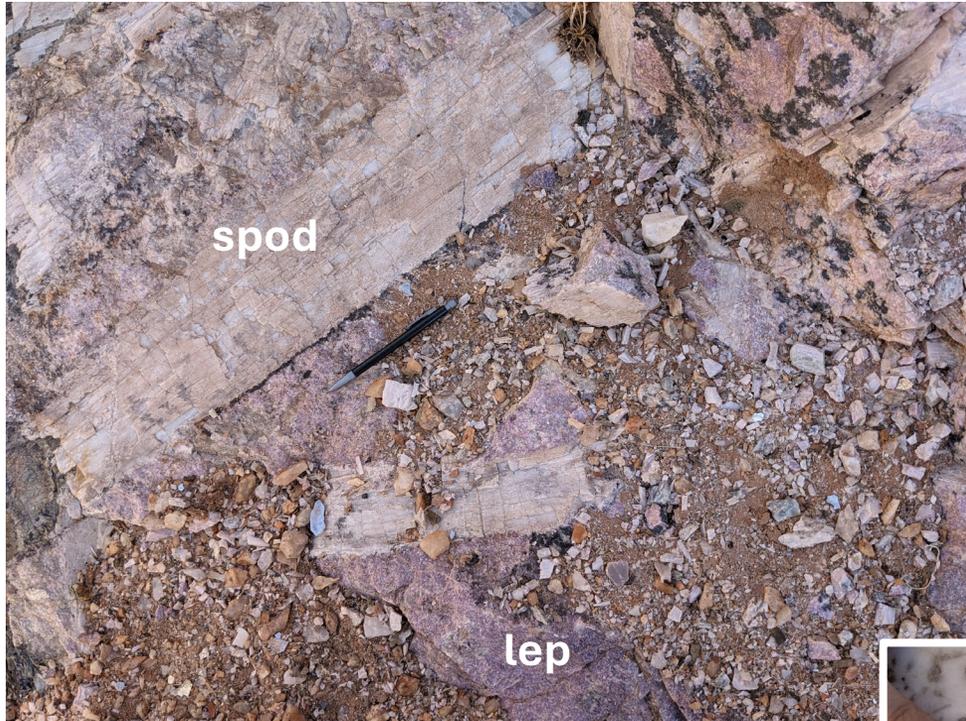
#1: Li-Pegs of the Monashee Complex



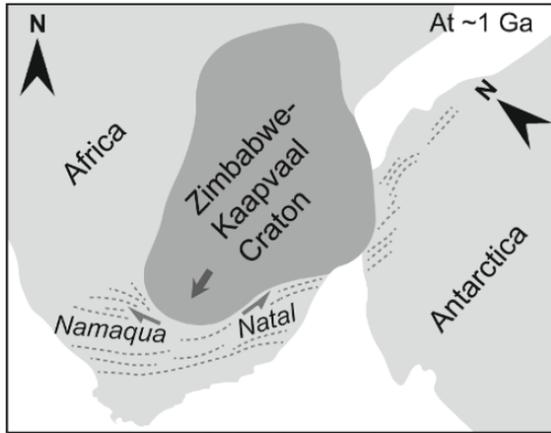
Cawood et al. (in press), after Vanderhaege, 1999.

Potential Evidence for Orogenic Collapse:	
Late high-T low-P meta	✗
Thinned lithosphere	✓
Metamorphic core complexes	✓
Low-angle detachment structures	✓
Gently dipping fol ± stretching lin	✓
Steep metamorphic gradients	✓
Basins with coarse clastic sediments	✓
Shallow supracrustals preserved	✓

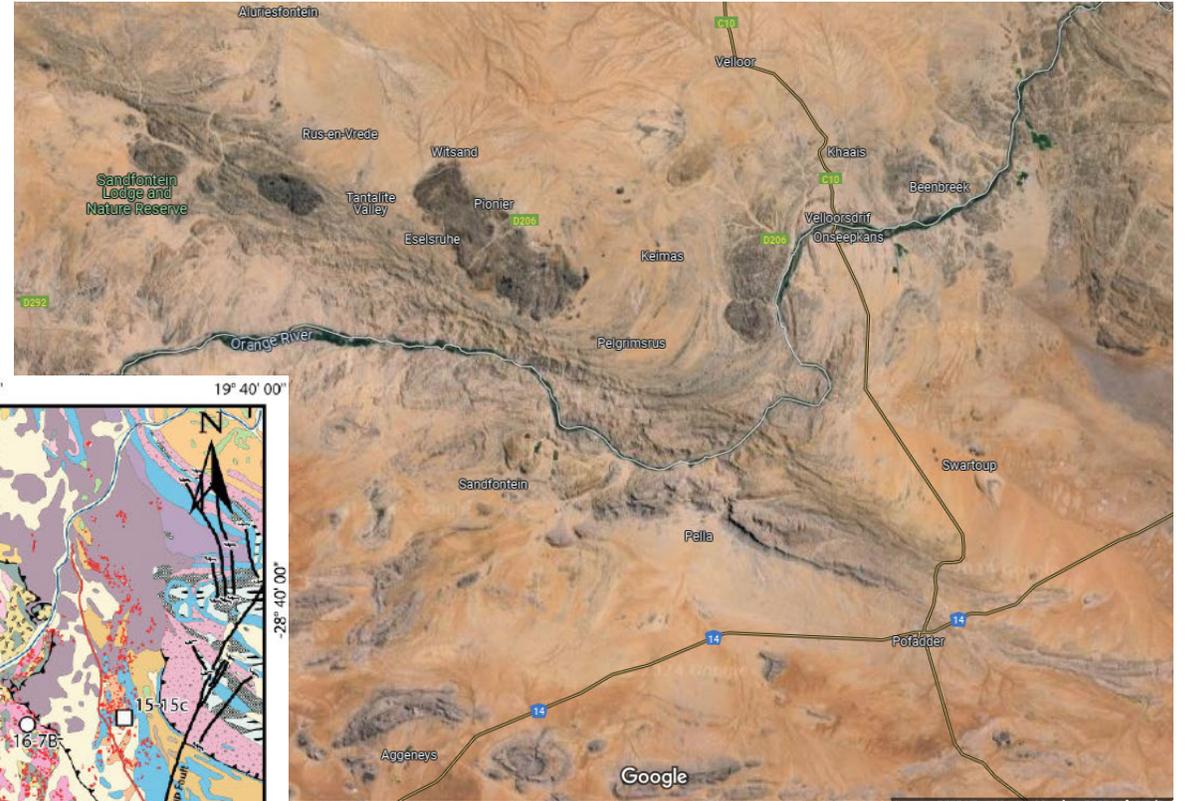
#2: Orange River Pegmatite Belt



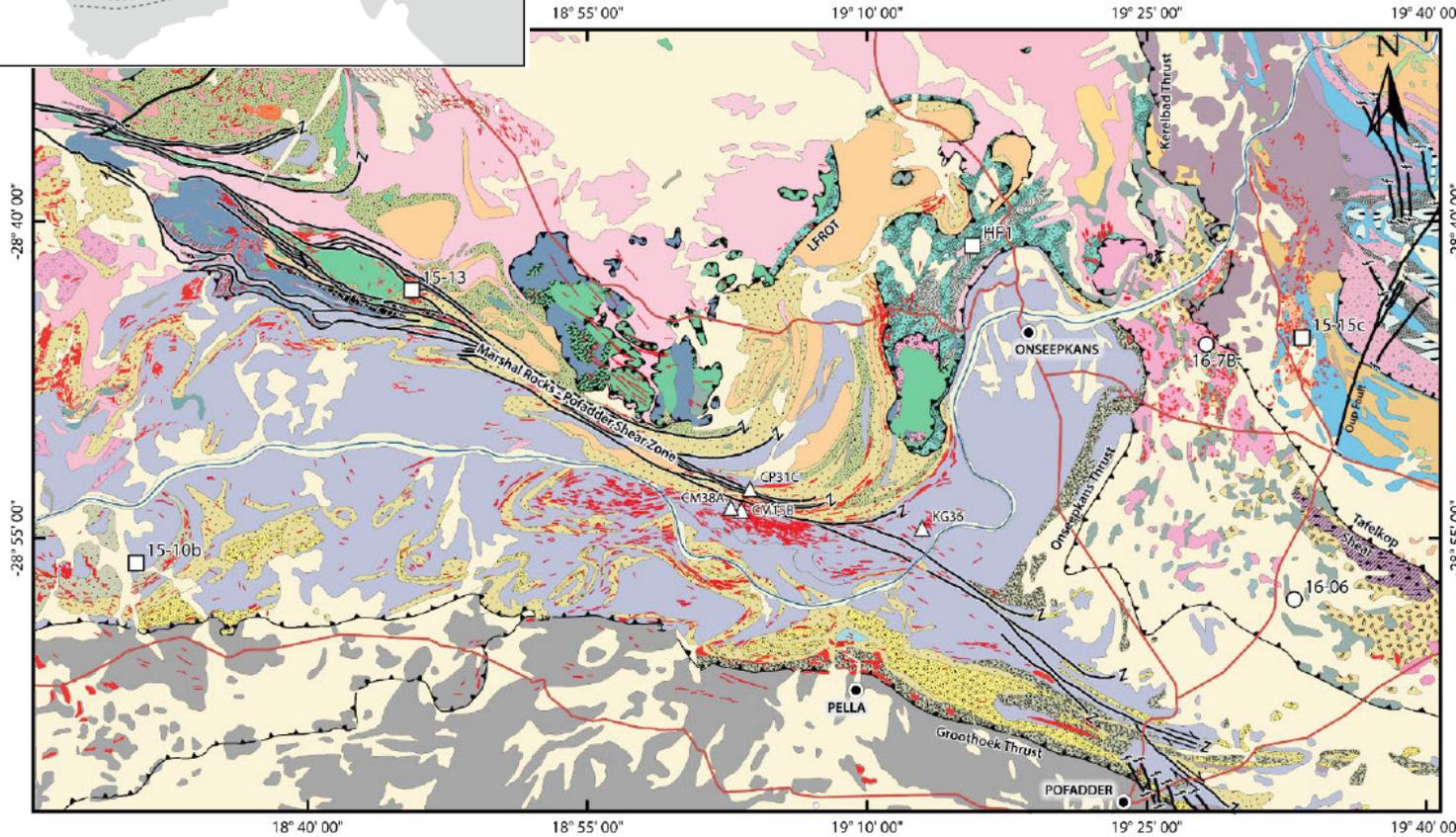
#2: Orange River Pegmatite Belt



Cawood et al., 2023, Ore Geology Reviews;
after Jacobs et al., 1993, Geology

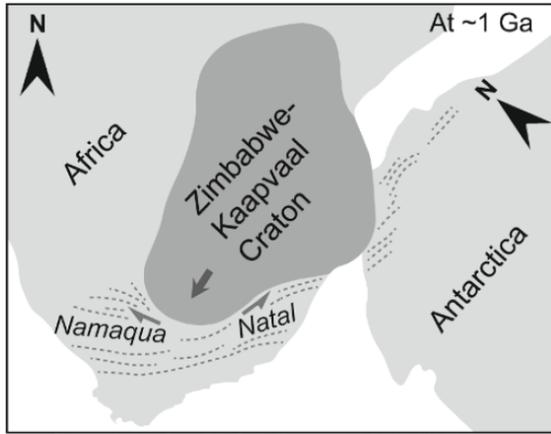


Google Maps, 2024

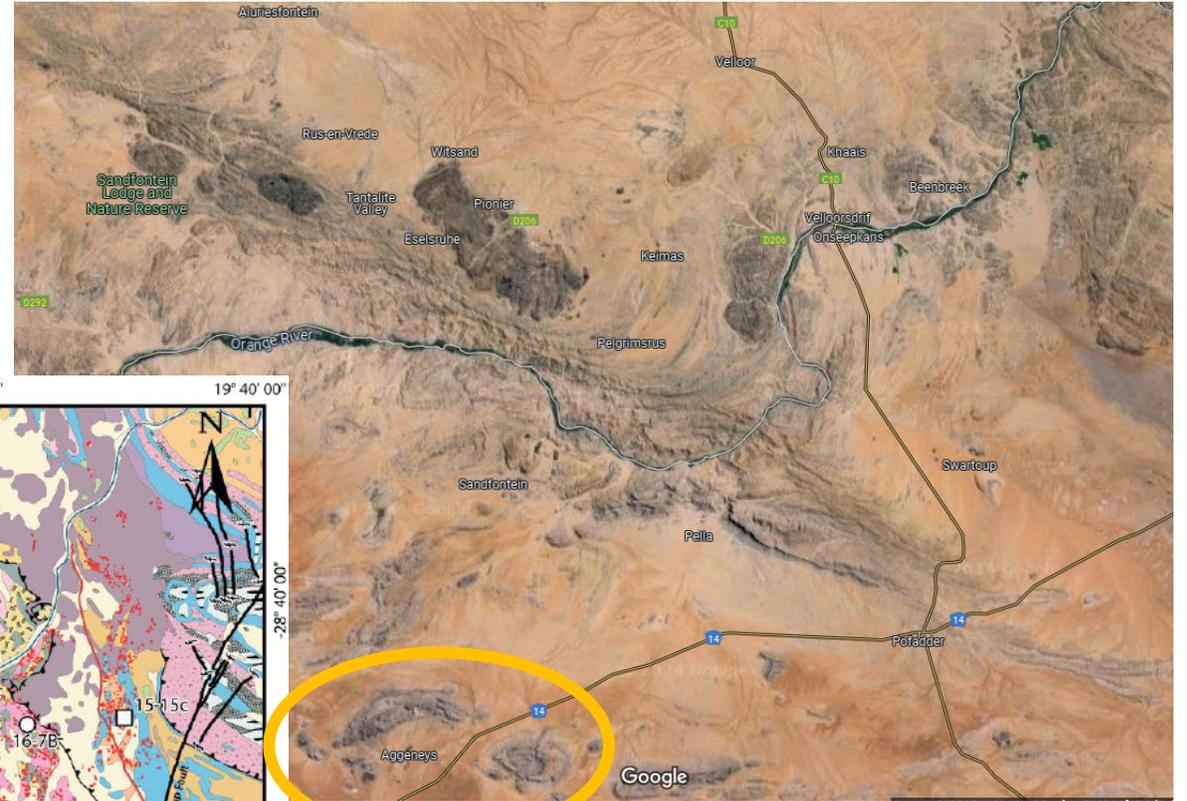


Doggart, 2019, M.Sc.

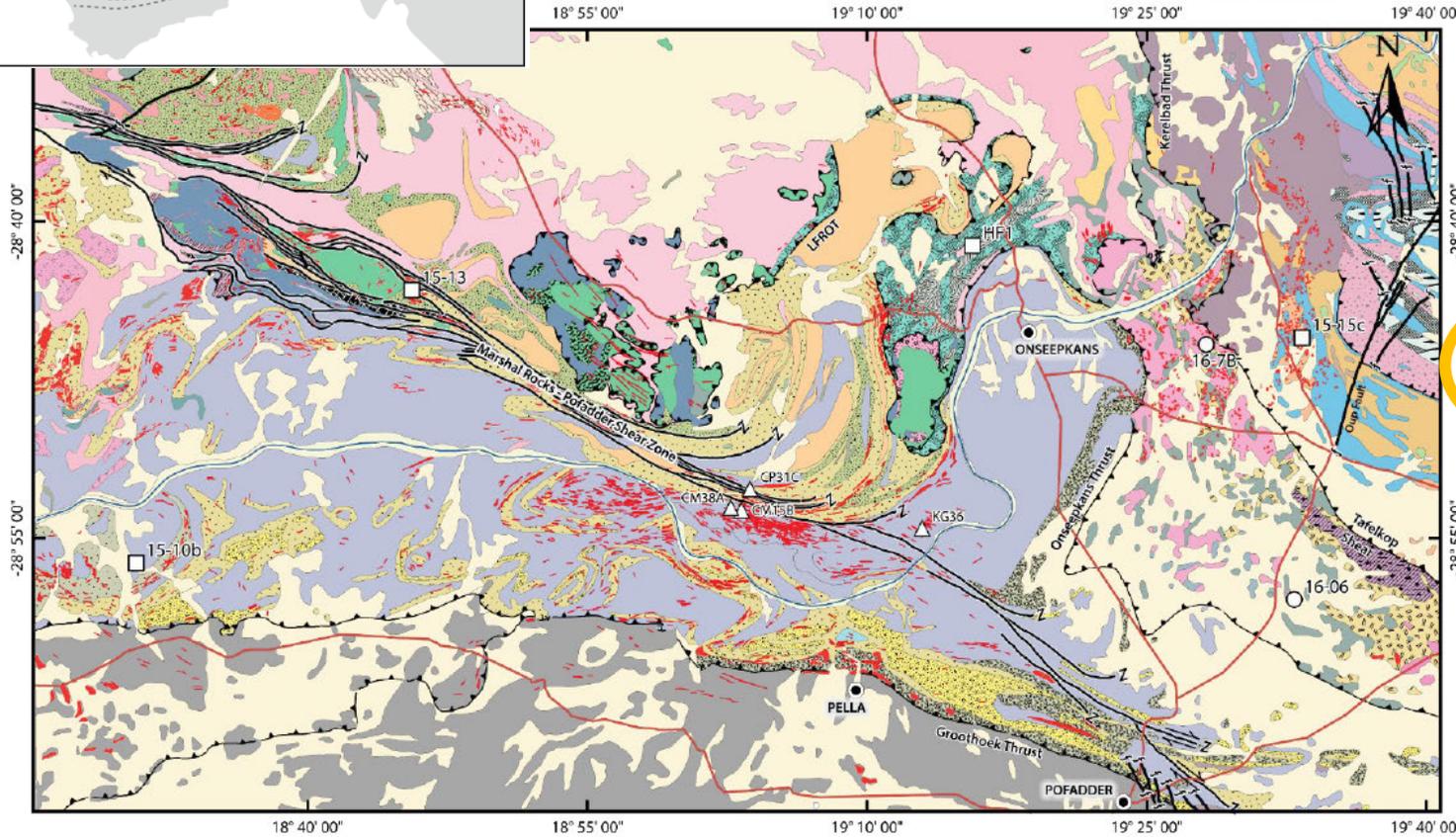
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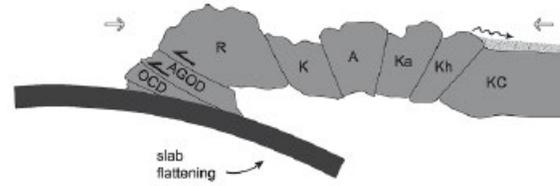
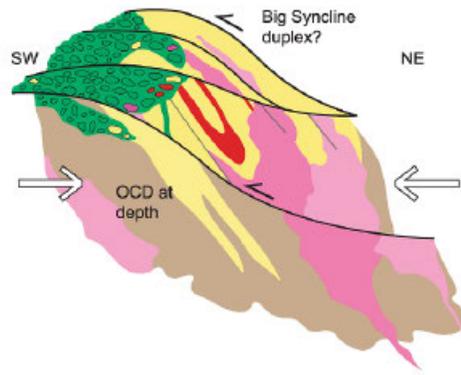
Google Maps, 2024



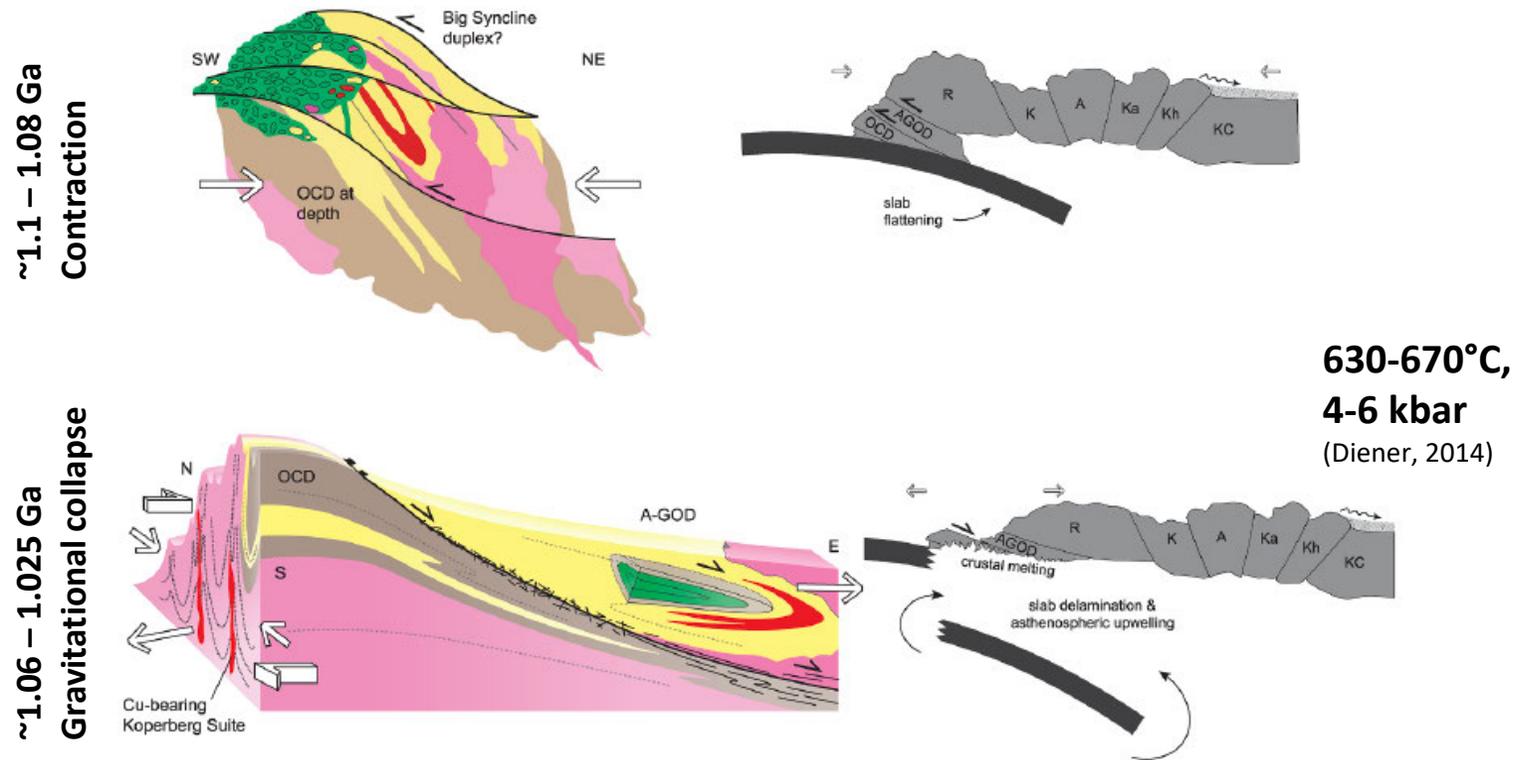
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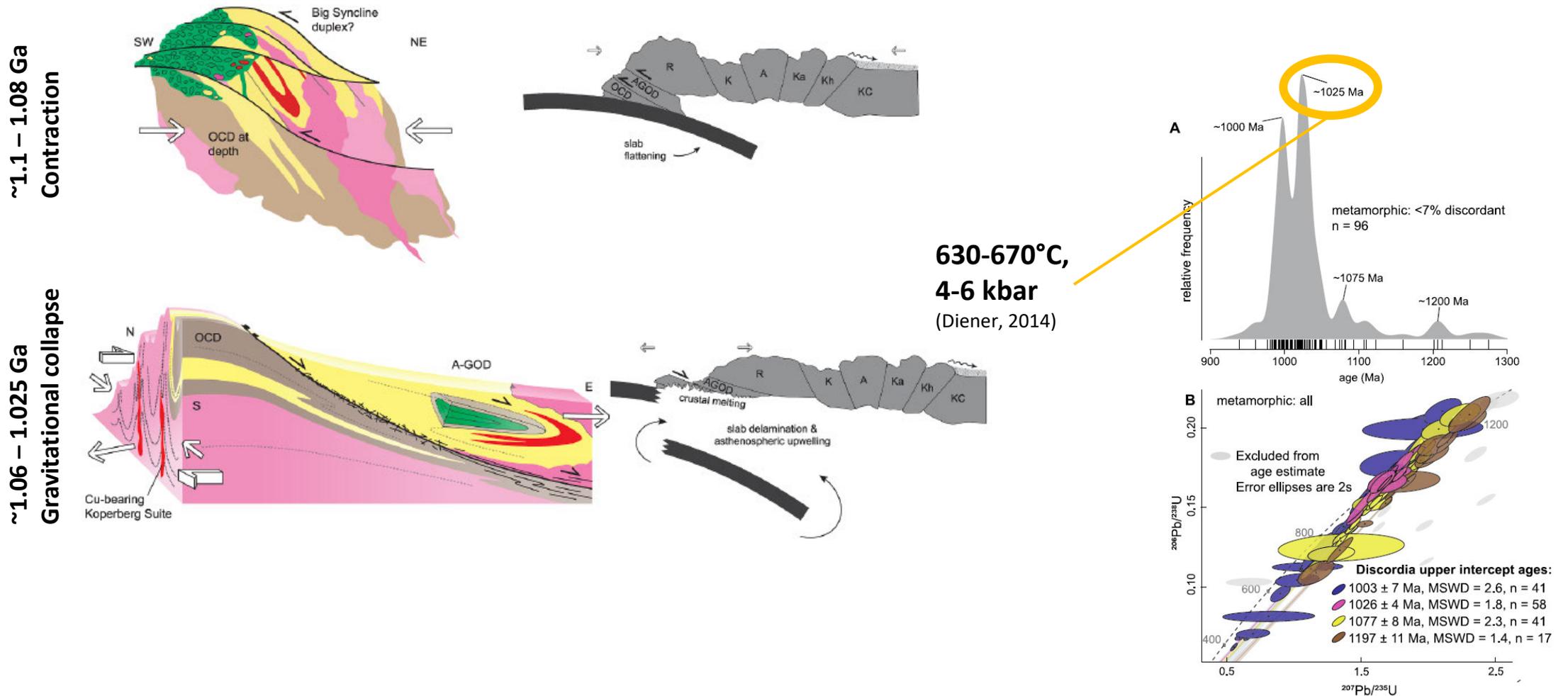
~1.1 – 1.08 Ga
Contraction



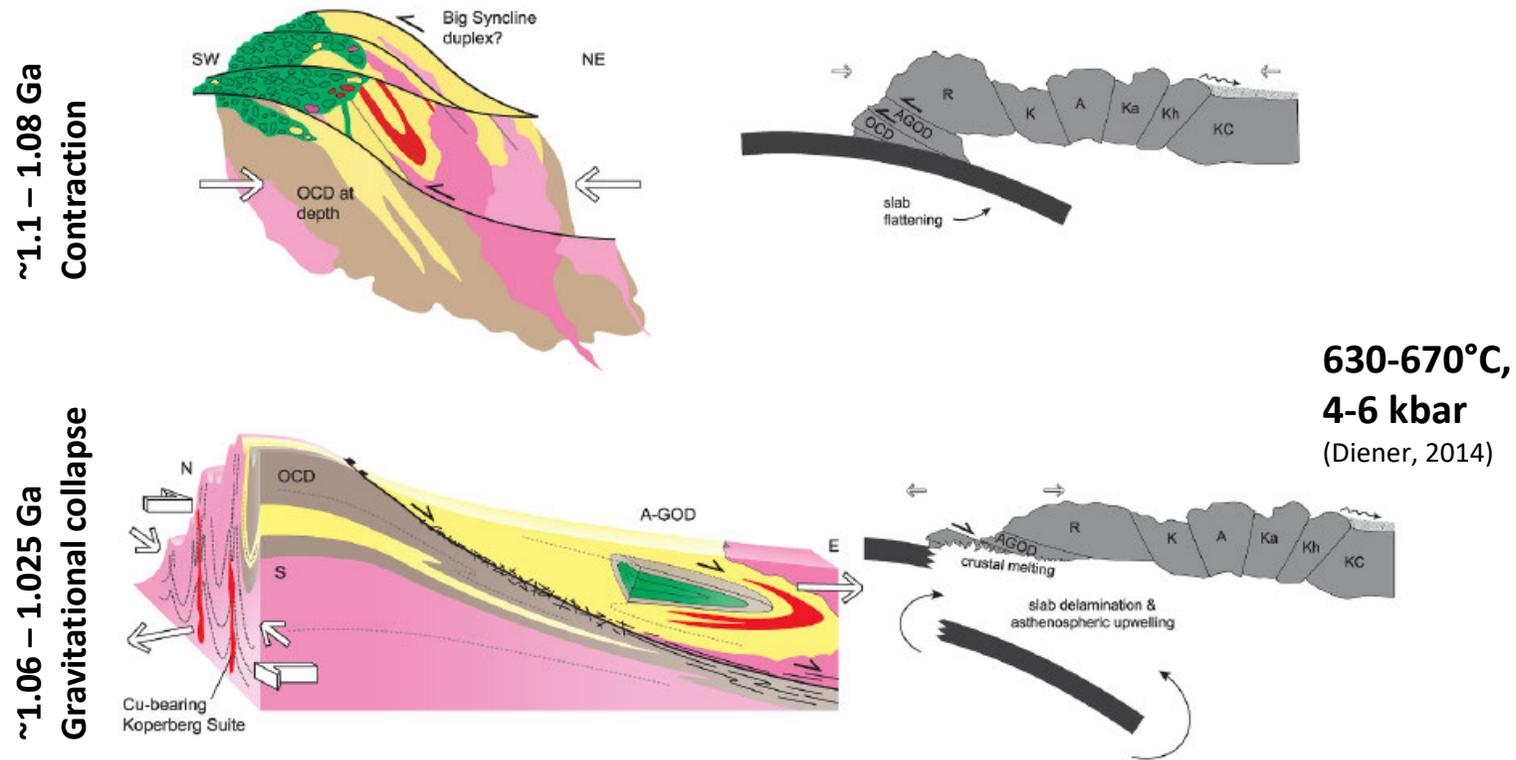
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#2: Orange River Pegmatite Belt



#2: Orange River Pegmatite Belt

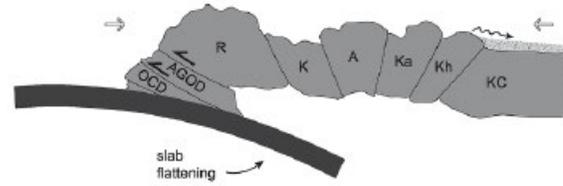
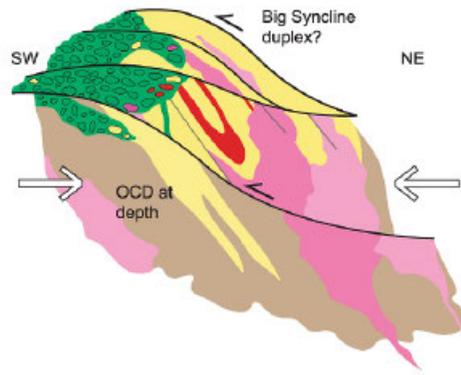


Potential Evidence for Orogenic Collapse:

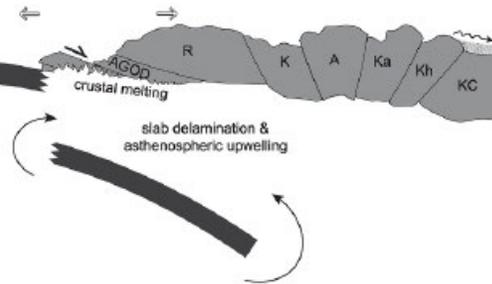
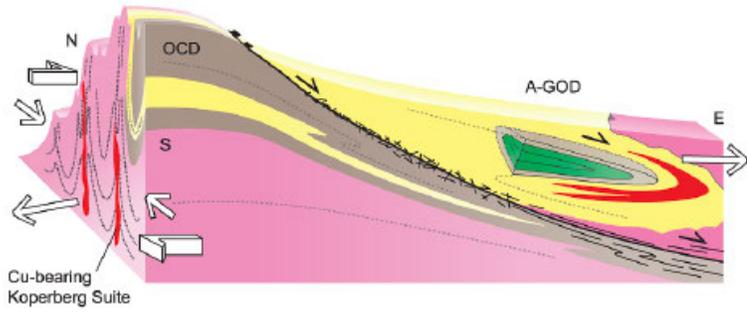
Late high-T low-P meta	✓
Thinned lithosphere	?
Metamorphic core complexes	?
Low-angle detachment structures	✓
Gently dipping fol ± stretching lin	✓
Steep metamorphic gradients	✗
Basins with coarse clastic sediments	✓
Shallow supracrustals preserved	✓

#2: Orange River Pegmatite Belt

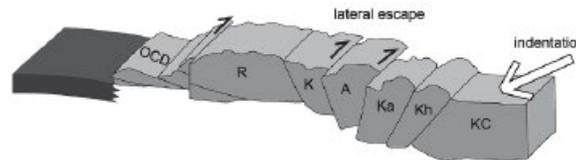
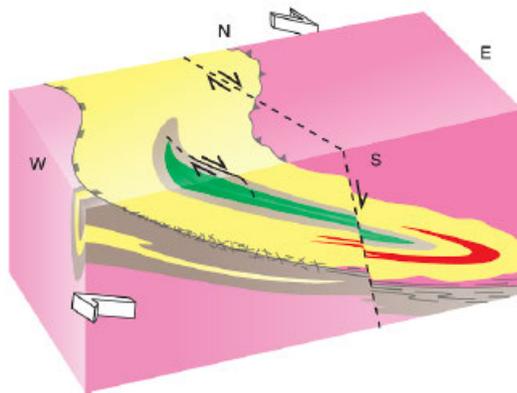
~1.1 – 1.08 Ga
Contraction



~1.06 – 1.025 Ga
Gravitational collapse

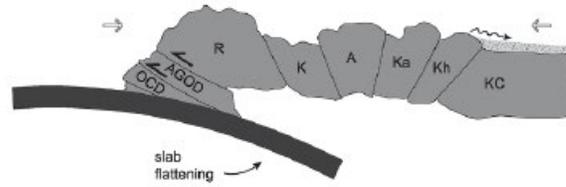
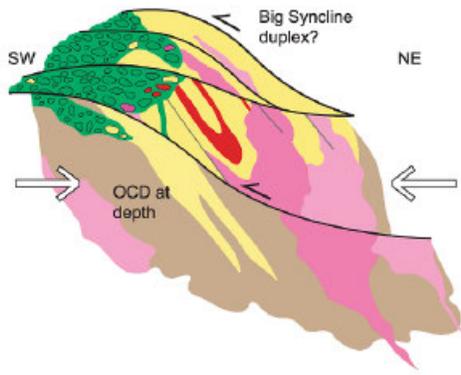


~1.00 – 0.96 Ga
Lateral escape

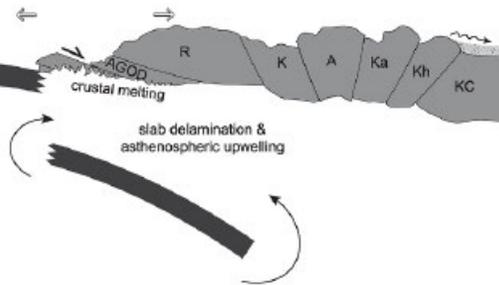
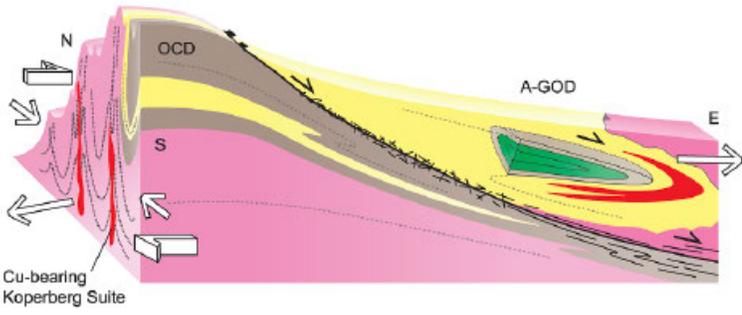


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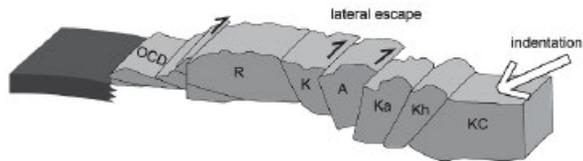
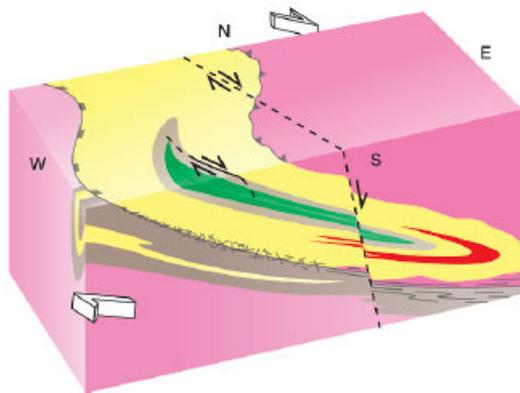
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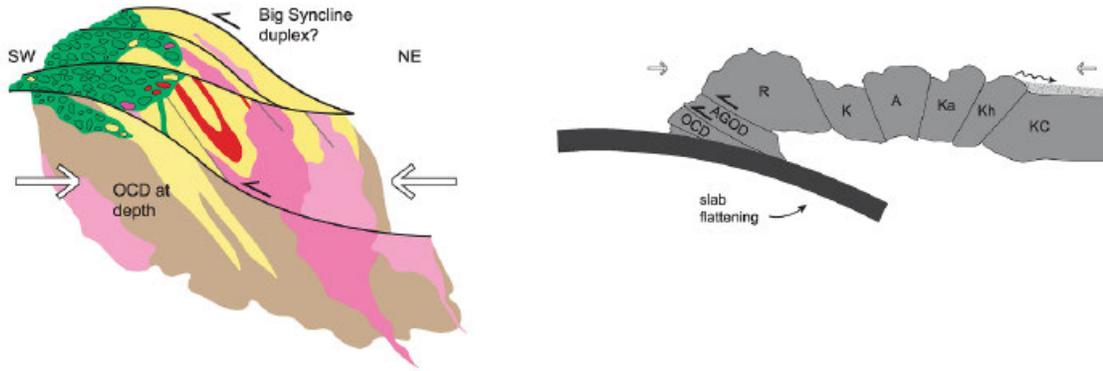
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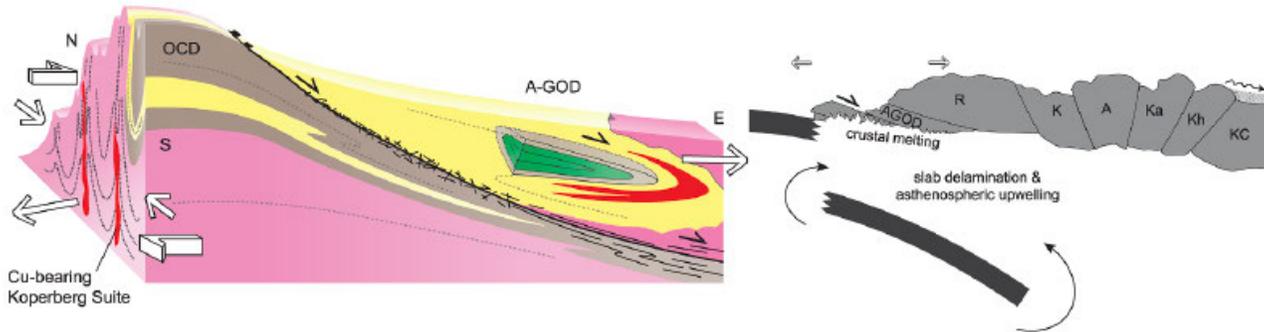
Pofadder SZ ~1005-960 Ma
(peg monazite U-Pb: Lambert, 2013)

#2: Orange River Pegmatite Belt

~1.1 – 1.08 Ga
Contraction

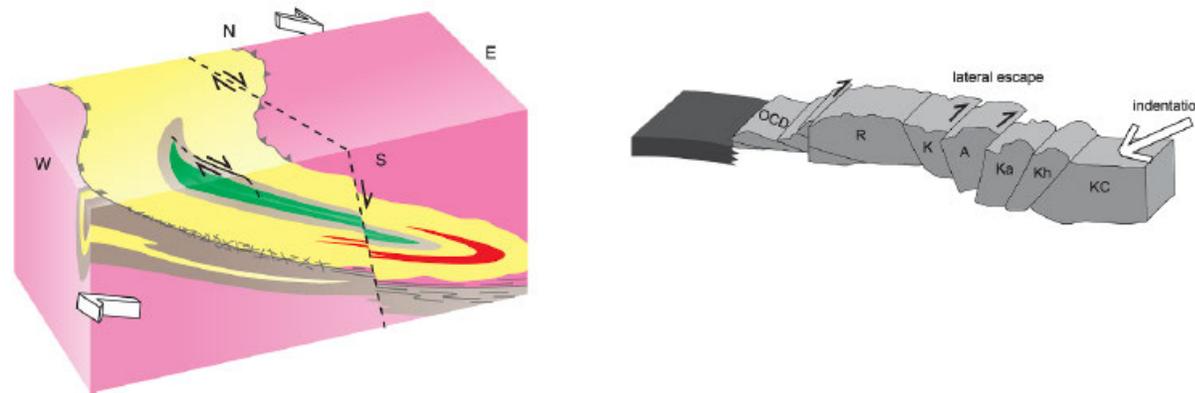


~1.06 – 1.025 Ga
Gravitational collapse



~1038-960 Ma pegmatites
(monazite U-Pb: Doggart, 2019)

~1.00 – 0.96 Ga
Lateral escape



Pofadder SZ ~1005-960 Ma
(peg monazite U-Pb: Lambert, 2013)

#3: Other Examples

Uis, Namibia

Classification, mineralogical and geochemical variations in pegmatites of the Cape Cross-Uis pegmatite belt, Namibia



Warrick C. Fuchsloch *, Paul A.M. Nex, Judith A. Kinnaird

School of Geosciences, University of the Witwatersrand, South Africa

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ABSTRACT

The Pan African aged Damara Orogen in Namibia is host to the Cape Cross-Uis pegmatite belt, one of several NE-trending pegmatite belts which host Li, Nb, Ta and Sn mineralisation. Field mapping and structural analysis of thirty seven pegmatite bodies has shown that the pegmatites intrude along crustal weaknesses such as fold axes and bedding planes, predominantly following the approximate NE orientated regional structural fabric. The lack of deformation together with cross-cutting relationships mapped, suggest that pegmatites were emplaced during post-tectonic extension that resulted from end-orogeny crustal relaxation. Based on mineralogy, geochemistry and ore mineralogy, three groups of pegmatites are distinguished within the Cape Cross-Uis

ites added largely to the thermal metamorphism of the belt. Longridge (2012), however, shows that peak metamorphism at 520 Ma in the Damara Orogen, caused by crustal relaxation and orogenic collapse, was responsible for providing the heat that produced the Salem-type granites and pegmatites. Pegmatites show no evidence of contact aureoles and must have been a product of thermal metamorphism and not

Fuchsloch et al., 2018

Côte d'Ivoire

Therefore, our preferred model for the formation of the rare metal pegmatites in Issia (Fig. 12a-b-c) is as follows: upwelling of the asthenosphere in a post-collision extension environment entrained decompression, and additional heat induced partial melting (1%) of the G3 fertile granite, and possibly surrounding sedimentary rocks, at ca. 2050 Ma (Fig. 12a). The formed flux-rich (B+P+F) and rare-metal bearing magma moved upward through extension fractures, before crystallizing as LCT pegmatites (Fig. 12b). Finally, the very long erosion period led to redistribution of the rare

Brou et al., 2022

Maine, USA

acadian ~340 Ma). Thus, we suggest that Mt. Mica may be related to a later anatectic melt formed during a thermal event related to the transition from the Alleghanian orogeny to the onset of Triassic continental breakup. We suggest that the Mt. Mica

Simmons et al., 2016

Elba island, Italy

along a down-to-east extensional detachment. Extension was syn-magmatic (Smith and others, 2010) and was a consequence of slab rollback of the lower plate (Malinverno and Ryan, 1986). Magmatism, mainly crustal melts with a mantle influence, was the consequence of decompression melting because of extension (Malinverno and Ryan, 1986) or lower-plate delamination (Serra and others, 1993). All of this hap-

Bradley et al., 2017

Sveconorwegian orogen

Pangea (Bradley and others, 2012). In the Paleoproterozoic Sveconorwegian collisional orogen of Sweden, lepidolite-bearing pegmatites were emplaced after deformation and metamorphism, and just before late-orogenic extensional collapse (Romer and Smeds, 1996). In a new synthesis of Siberian

Bradley et al., 2017

Damara Belt

Longridge et al. (2014, 2018) showed that peak metamorphic conditions in the Damara Belt, caused by crustal relaxation and orogenic collapse, reached up to 850 °C, high enough to facilitate the fluid-absent melting of biotite in the Damaran metapelitic and meta-igneous

Ashworth et al. 2020

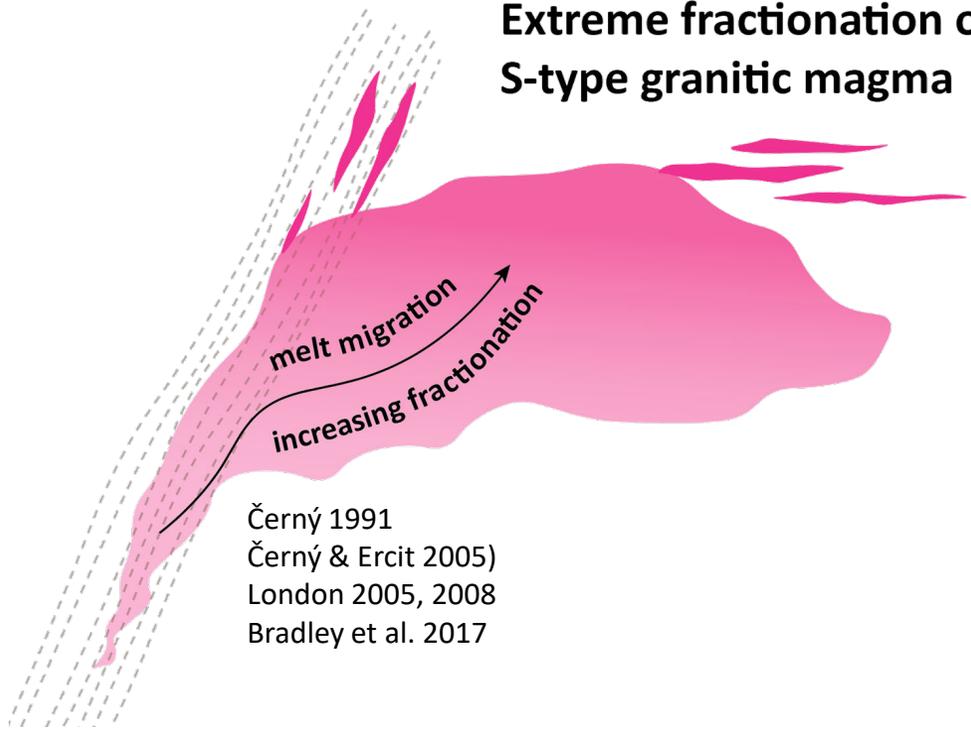
Siberia

lapse (Romer and Smeds, 1996). In a new synthesis of Siberian pegmatites, Zagorsky and others (2014) related the Ordovician Tastyg and Sutlug pegmatites of the South Sangilen province to a transition from collision to post-collisional extension and strike-slip.

Bradley et al., 2017

Model

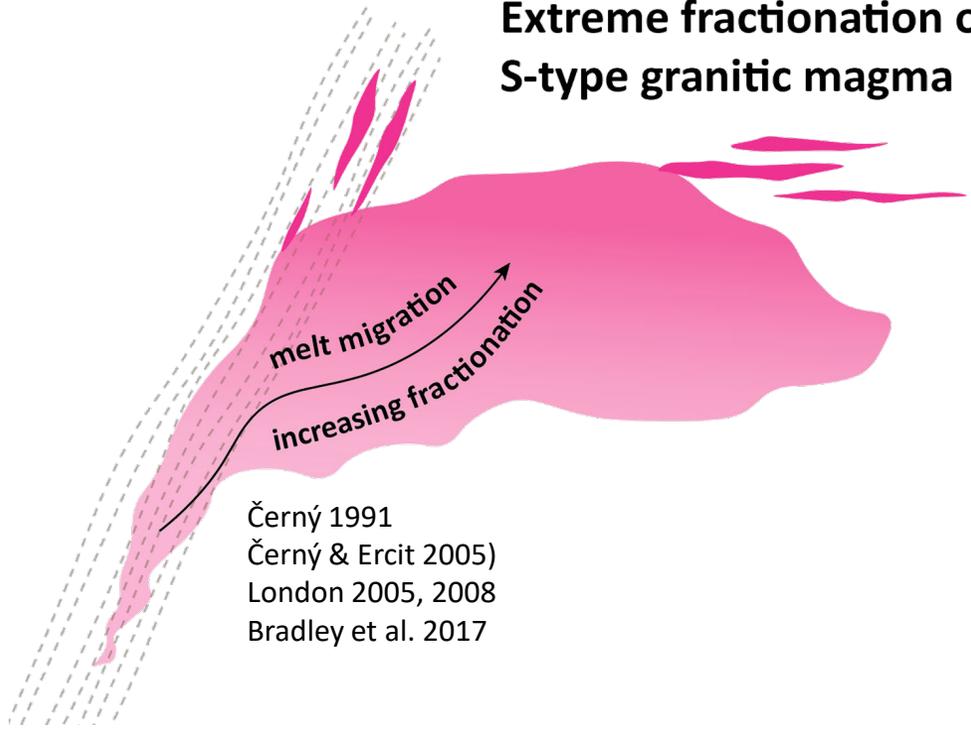
Extreme fractionation of
S-type granitic magma



Černý 1991
Černý & Ercit 2005)
London 2005, 2008
Bradley et al. 2017

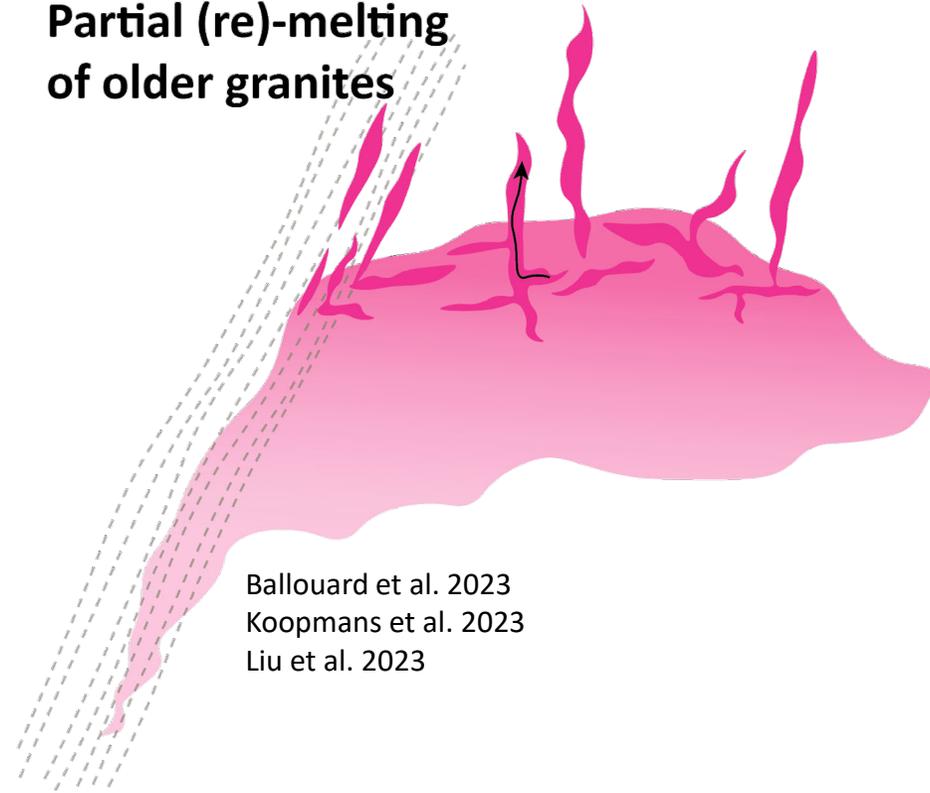
Model

Extreme fractionation of S-type granitic magma



Černý 1991
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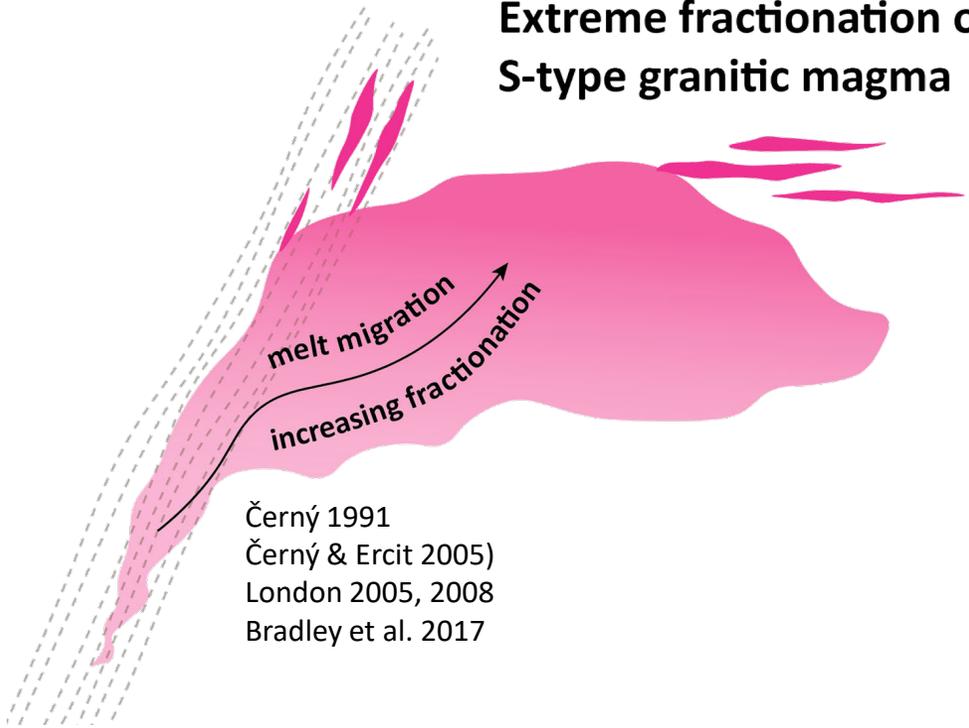
Partial (re)-melting of older granites



Ballouard et al. 2023
Koopmans et al. 2023
Liu et al. 2023

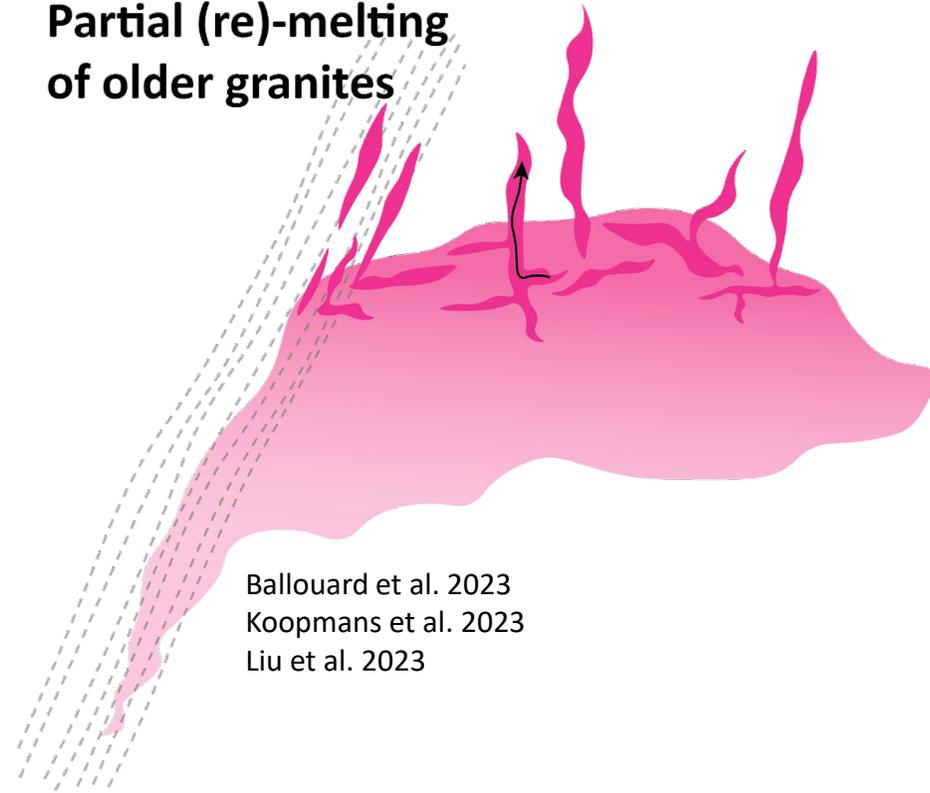
Model

Extreme fractionation of S-type granitic magma



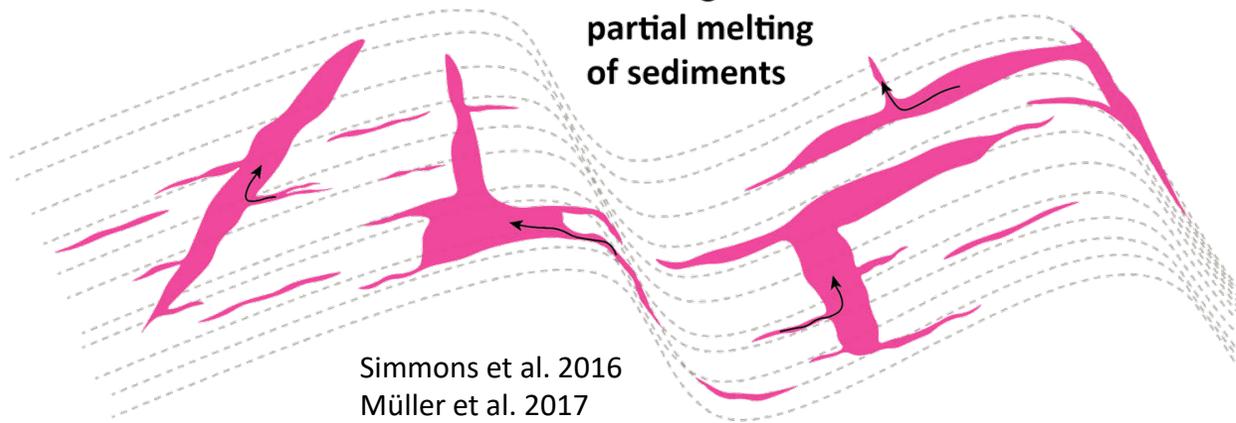
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Partial (re)-melting of older granites



Ballouard et al. 2023
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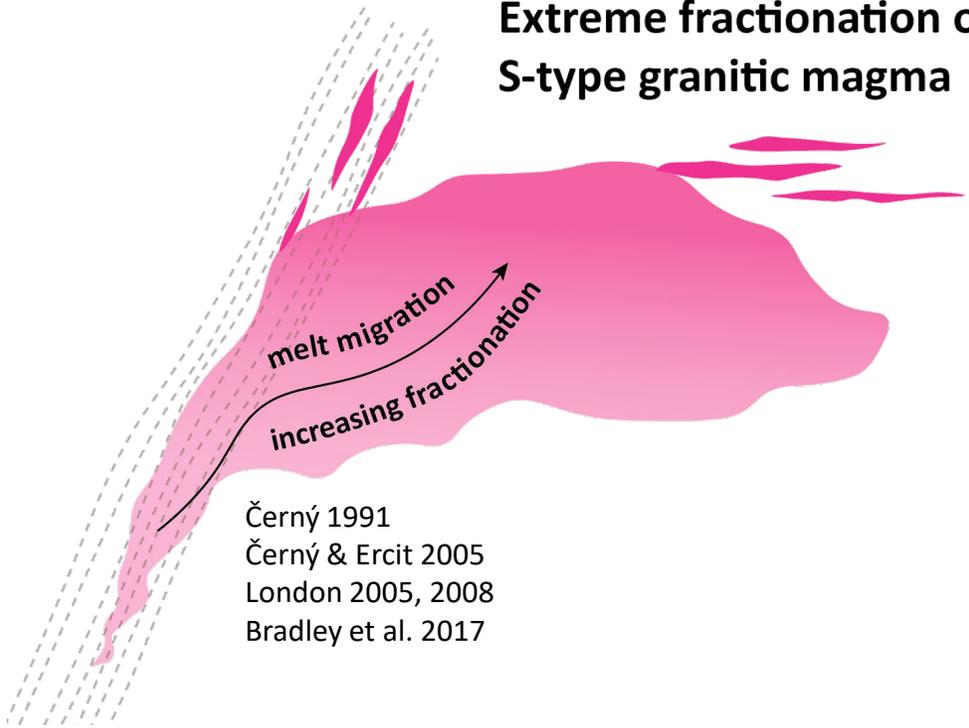
Low-degree partial melting of sediments



Simmons et al. 2016
Müller et al. 2017
Fuchsloch et al. 2018
Doggart 2019

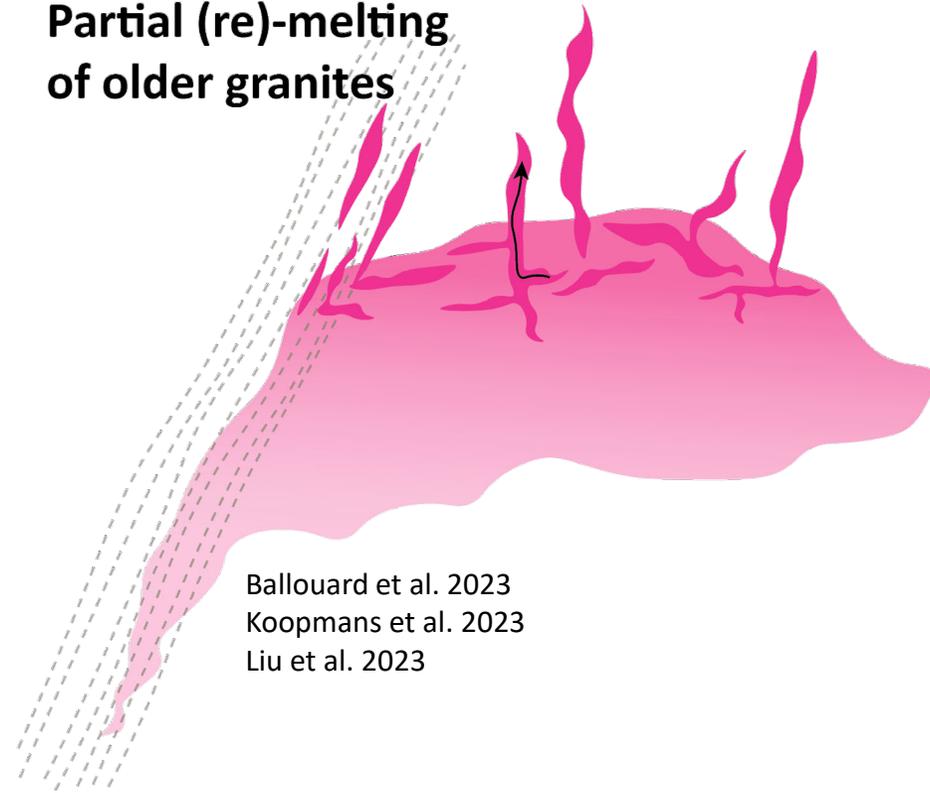
Model

Extreme fractionation of S-type granitic magma



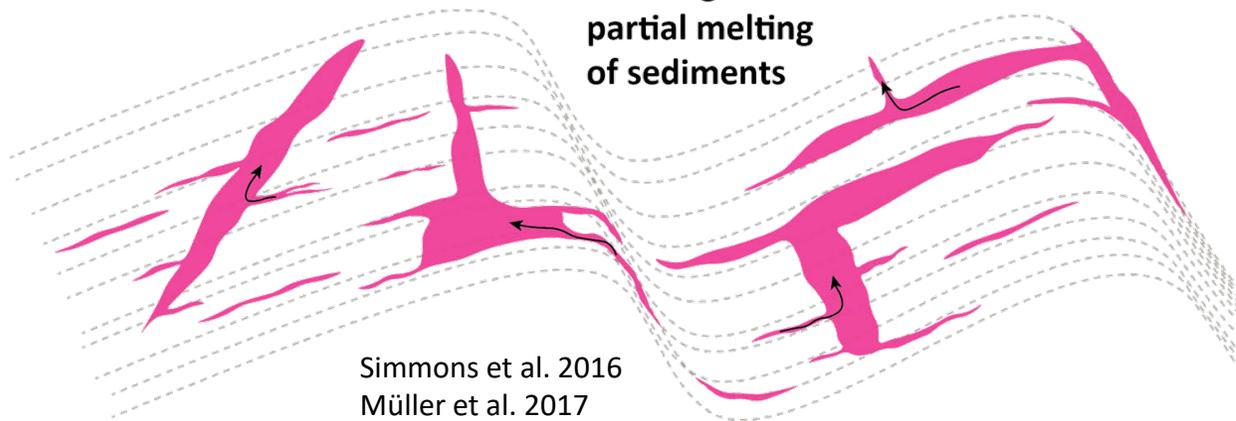
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Partial (re)-melting of older granites



Ballouard et al. 2023
Koopmans et al. 2023
Liu et al. 2023

Low-degree partial melting of sediments



Simmons et al. 2016
Müller et al. 2017
Fuchsloch et al. 2018
Doggart 2019

How to Induce Partial Melting:

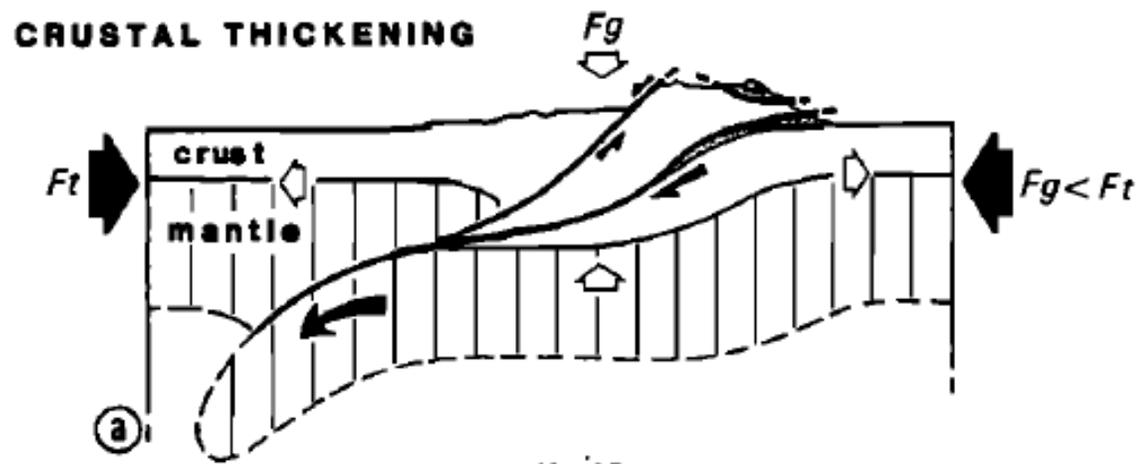
↑ T

↓ P

+ fluids

Silva et al. 2024

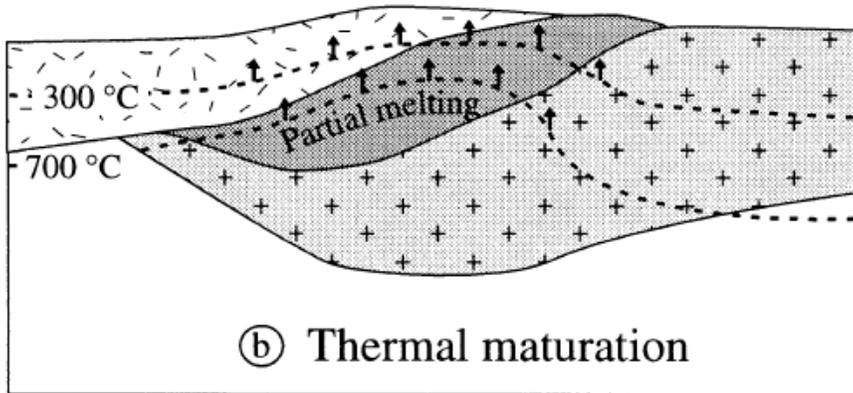
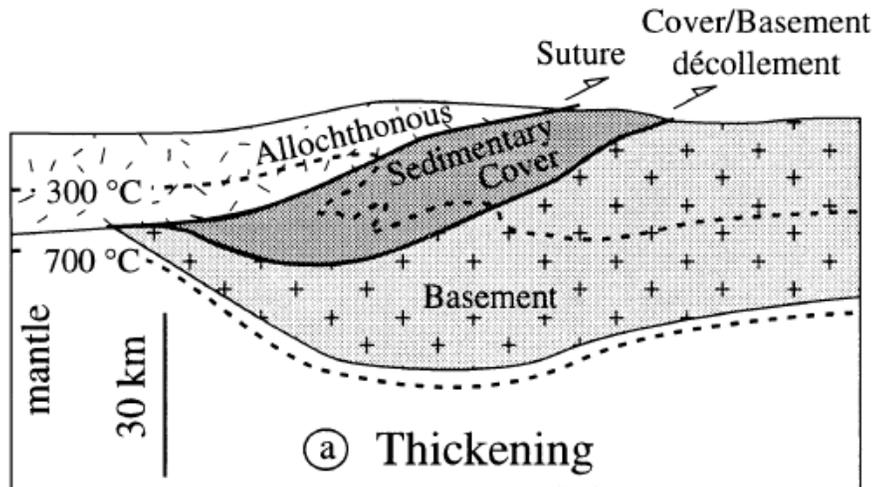
Model



Malavielle 1993, , Tectonics

- Subduction and/or thrust stacking delivers fertile, hydrous sediments \pm volcanics to depth = *SOURCE ROCKS*

Model

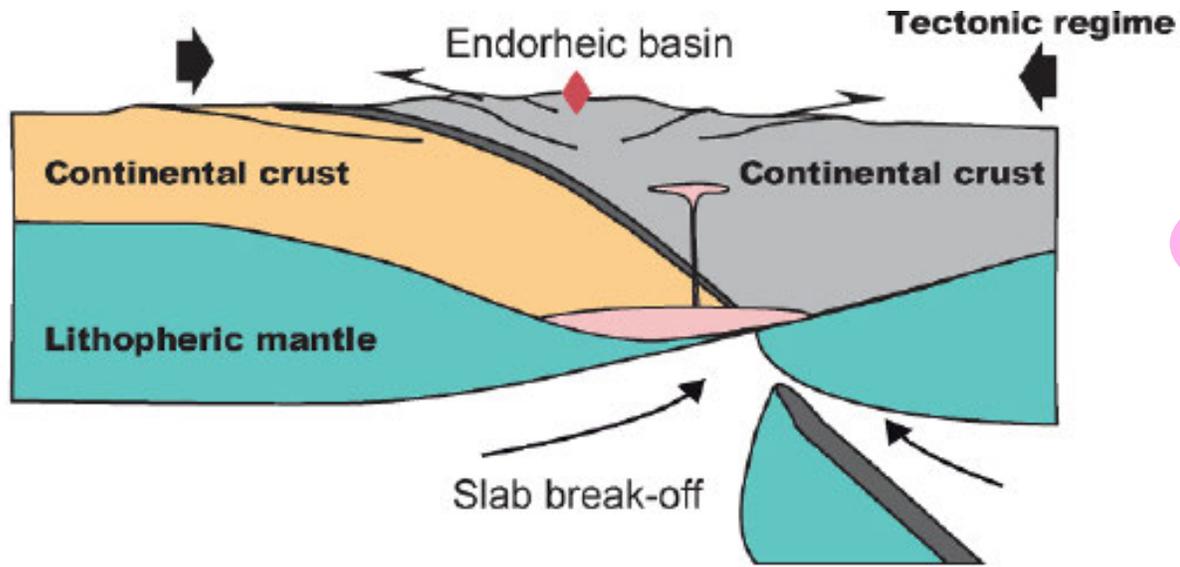


Vanderhaeghe & Teyssier 2001, Tectonophysics

- Subduction and/or thrust stacking delivers fertile, hydrous sediments ± volcanics to depth = *SOURCE ROCKS*
- Thermal relaxation of thickened lithosphere = *partial melting by slow $\uparrow T$, fluids*

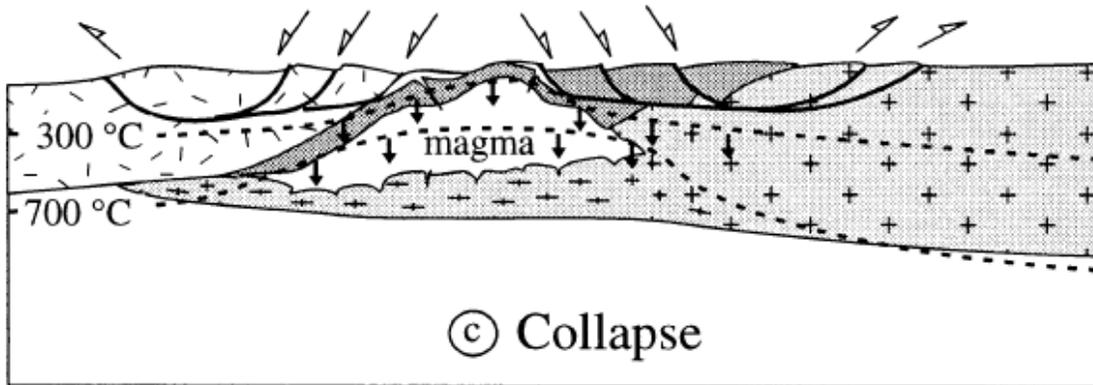
Li-pegs?

Model



- Subduction and/or thrust stacking delivers fertile, hydrous sediments \pm volcanics to depth = *SOURCE ROCKS*
- Thermal relaxation of thickened lithosphere = *partial melting by slow $\uparrow T$, fluids*
- Breakoff / delamination, asthenospheric upwelling = *partial melting by fast $\uparrow T$*

Model



Vanderhaeghe & Teyssier 2001, Tectonophysics

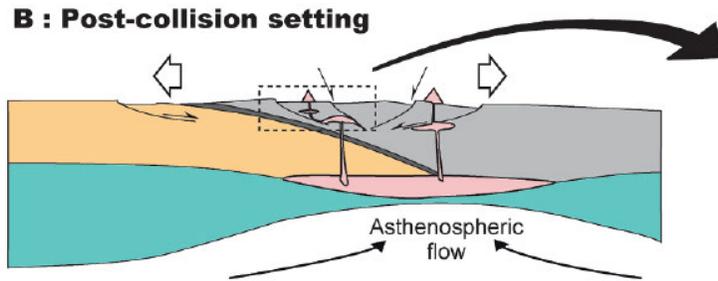
- **Subduction and/or thrust stacking delivers fertile, hydrous sediments ± volcanics to depth**
= *SOURCE ROCKS*
- **Thermal relaxation of thickened lithosphere**
= *partial melting by slow $\uparrow T$, fluids*
- **Breakoff / delamination, asthenospheric upwelling**
= *partial melting by fast $\uparrow T$*
- **Gravitational collapse, tectonic exhumation**
= *partial melting by $\downarrow P$*
= *extensional structures to transport & trap melt*

Li-pegs?

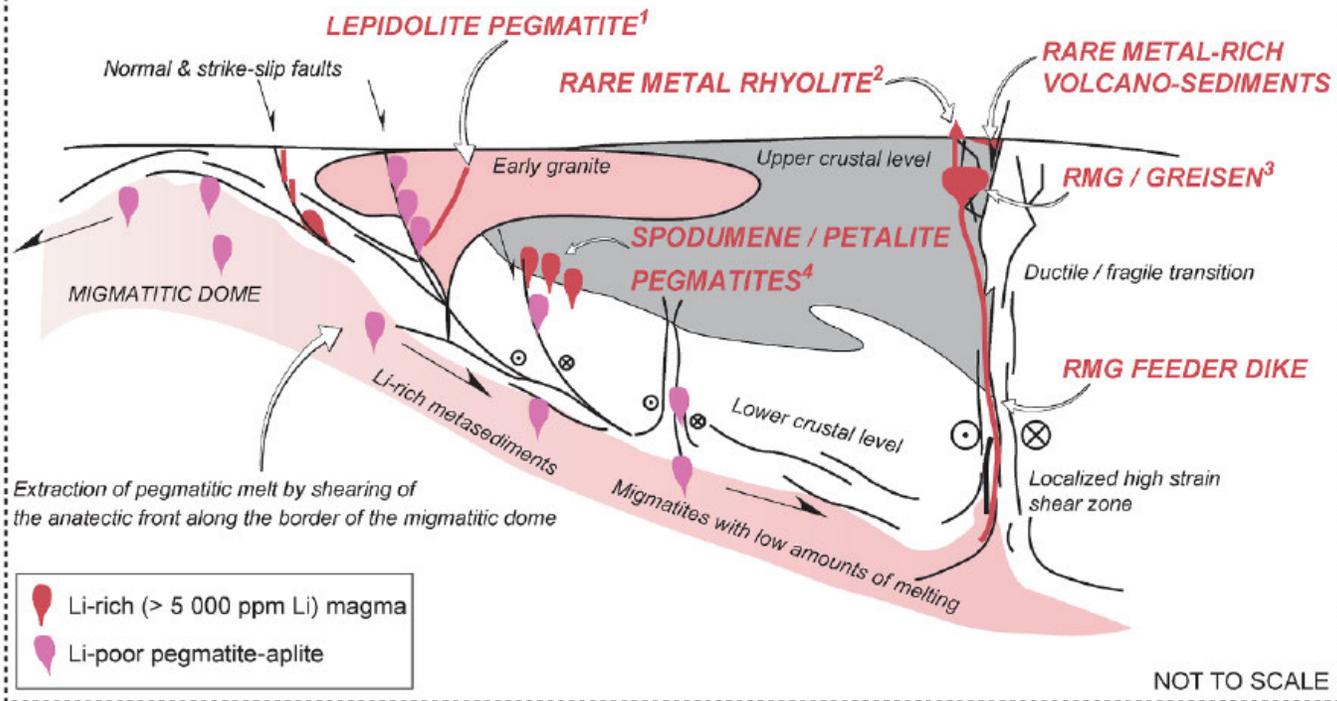
Li-pegs!

Li-pegs!

Model

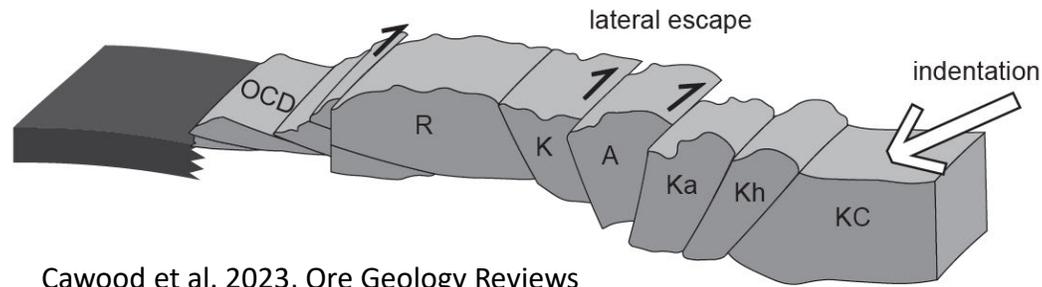


C : Post-collision / orogenic collapse and related Li-hard rock mineralization

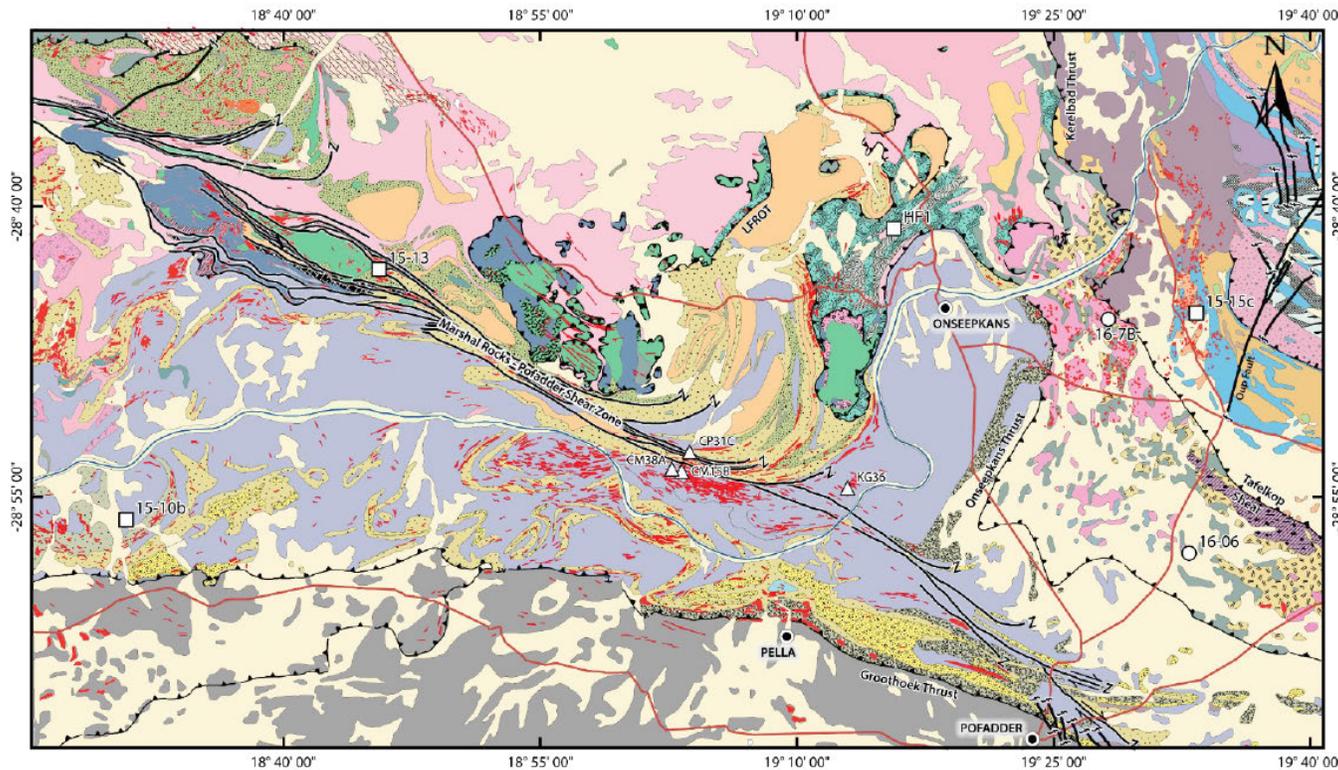


- Subduction and/or thrust stacking delivers fertile, hydrous sediments ± volcanics to depth = *SOURCE ROCKS*
- Thermal relaxation of thickened lithosphere = *partial melting by slow $\uparrow T$, fluids*
- Breakoff / delamination, asthenospheric upwelling = *partial melting by fast $\uparrow T$*
- Gravitational collapse, tectonic exhumation = *partial melting by $\downarrow P$*
= *extensional structures to transport & trap melt*

Model



Cawood et al. 2023, Ore Geology Reviews



Doggart, 2019, M.Sc.

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= *extensional structures to transport & trap melt*
- **Strike-slip deformation**
= *structures to transport & trap melt*

Is there a link between orogenic collapse and lithium-bearing pegmatites?

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