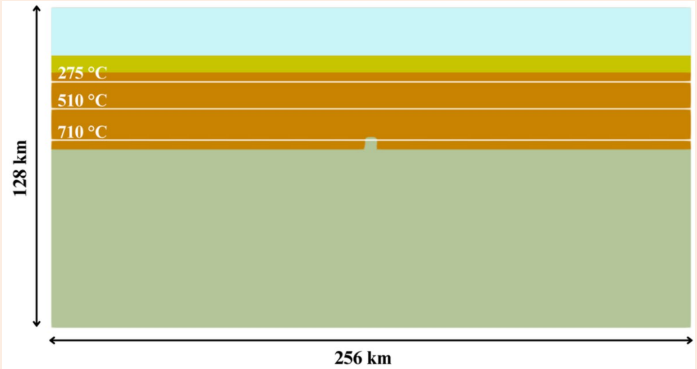
Investigating Granulite Facies Metamorphism in Proterozoic Rifted Basins, with examples from Broken Hill, New South Wales



In collaboration with Dr. Joel Fitzherbert and the Geological Survey of New South Wales.

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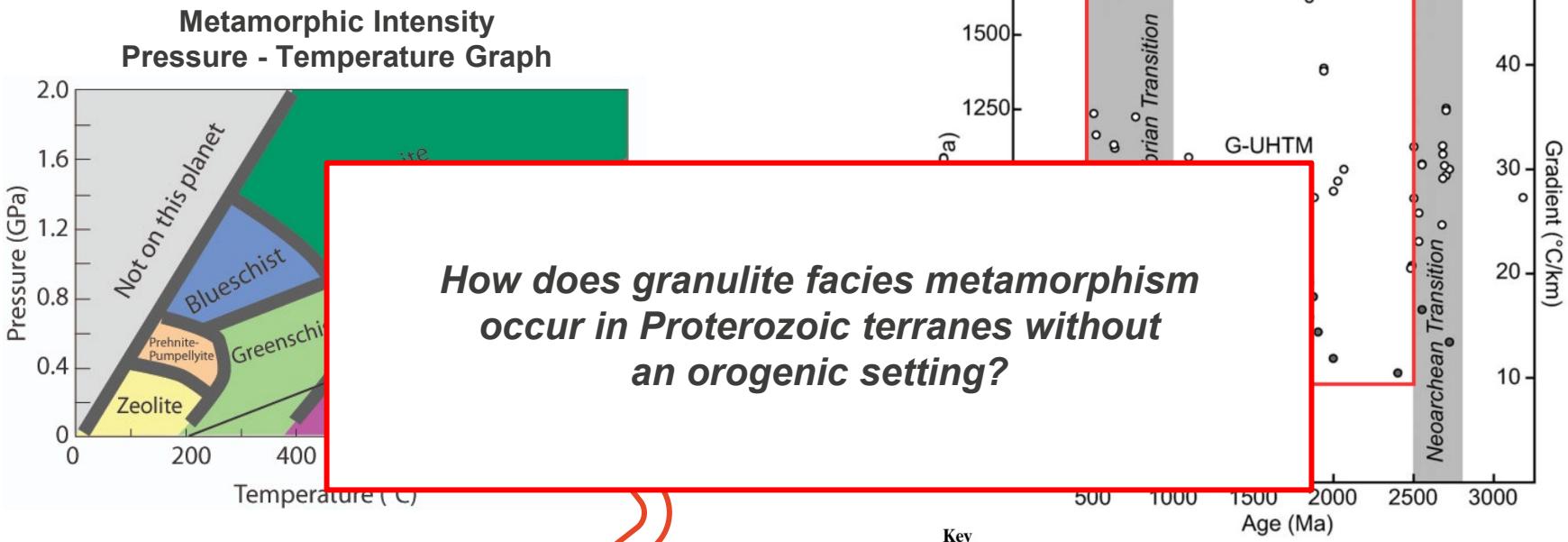
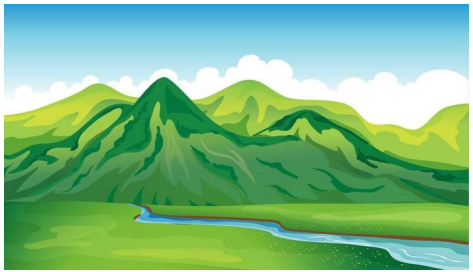
THE UNIVERSITY OF SYDNEY

Background



How does granulite facies metamorphism occur in Proterozoic terranes without an orogenic setting?



Occurs in orogenic settings on modern earth.

Figure modified from (Brown, 2006)

Objectives and Aims

Objective:
To investigate the mechanism/s behind regional low to medium-pressure, high-temperature granulite facies metamorphism in a Proterozoic setting.

Aim #1:
To *determine which mechanisms* can produce regional granulite facies metamorphism.

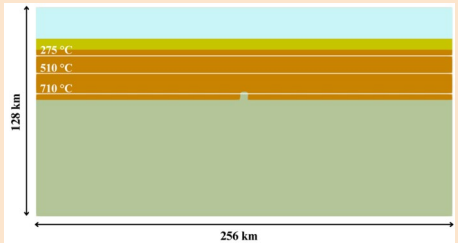
Aim #2:
To *understand the relationship between metamorphism and deformation*.

Methods

Pursuing Aim #1

Pursuing Aim #2

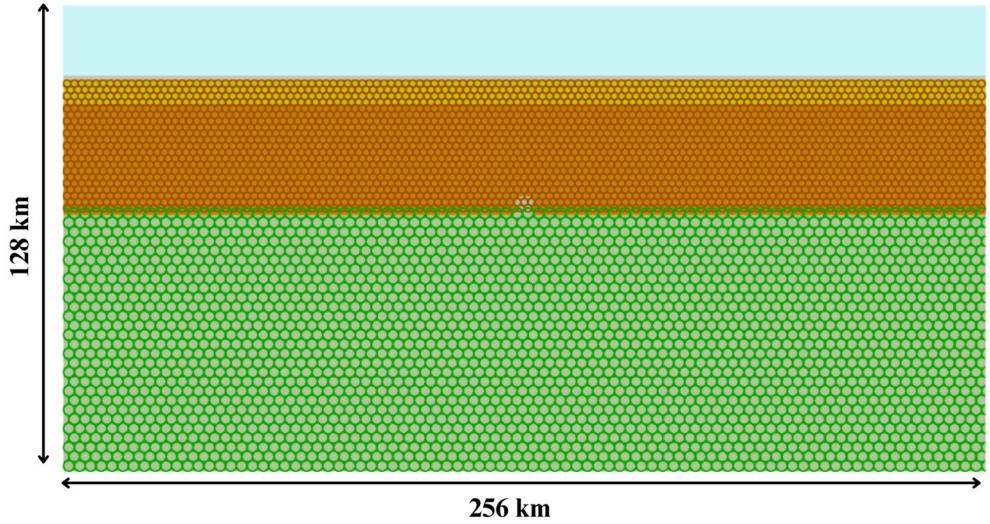
2D Numerical Experiments



Fieldwork in Broken Hill

Petrographic Analyses

2D Numerical Experiments in *Underworld*



Pursuing Aim #1

Testing the effectiveness of:

- ➔ **Extensional velocity**
- ➔ **Sedimentation rate**
- ➔ **Basal heat flow**
- ➔ **Melt emplacement** (New Method)

…as mechanisms for producing regional granulite facies metamorphism.

Pursuing Aim #2

Modelling the development of tectonic fabrics with ***finite strain ellipses.***

Numerical Experiment Results

Aim #1 Results

Extension alone is not observed to produce granulite facies metamorphism; an additional heat source is necessary.

Experiment Number	Experiment Name	Extension Velocity	Sedimentation Rate (mm/year)	Basal Heat Flow ($W.m^{-2}$)	Melt Added	Outcomes On Granulite Facies Temperatures In The Crust
1	Fast Rifting	Fast	0.6	-	-	Not produced
2	Slow Rifting	Slow	0.6	-	-	Not produced
3	Increased Sedimentation (Fast Rifting)	Fast	1.2	-	-	Not produced
4	Increased Sedimentation (Slow Rifting)	Slow	1.2	-	-	Not produced
5	Basal Heat Flow (Fast Rifting)	Fast	0.6	0.036	-	Produced
6	Basal Heat Flow (Slow Rifting)	Slow	0.6	0.036	-	Not produced
7	Melt (Fast Rifting)	Fast	0.6	-	YES	Produced
8	Melt (Increased Sedimentation & Fast Rifting)	Fast	1.2	-	YES	Produced
9	Melt (Basal Heat Flow & Fast Rifting)	Fast	0.6	0.036	YES	Produced
10	Melt (Basal Heat Flow & Slow Rifting)	Slow	0.6	0.036	YES	Produced

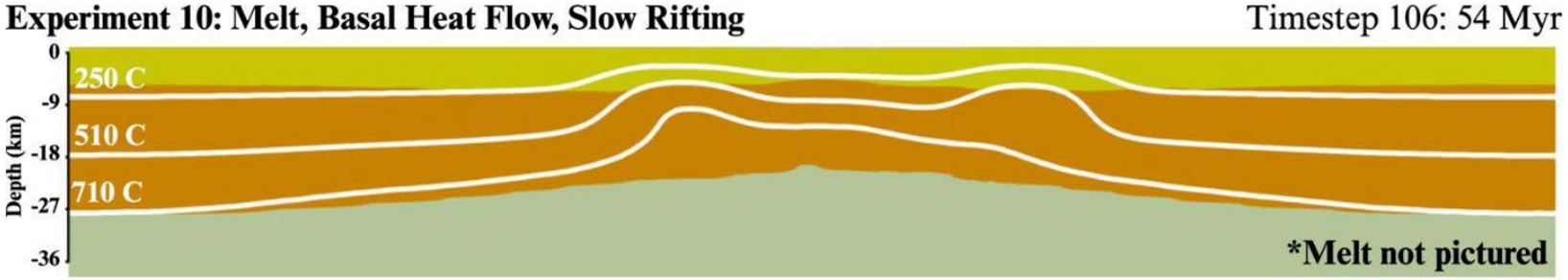
Basal heat flow ***under a fast rifting velocity***

All melt experiments

Numerical Experiment Results

Aim #1 Results

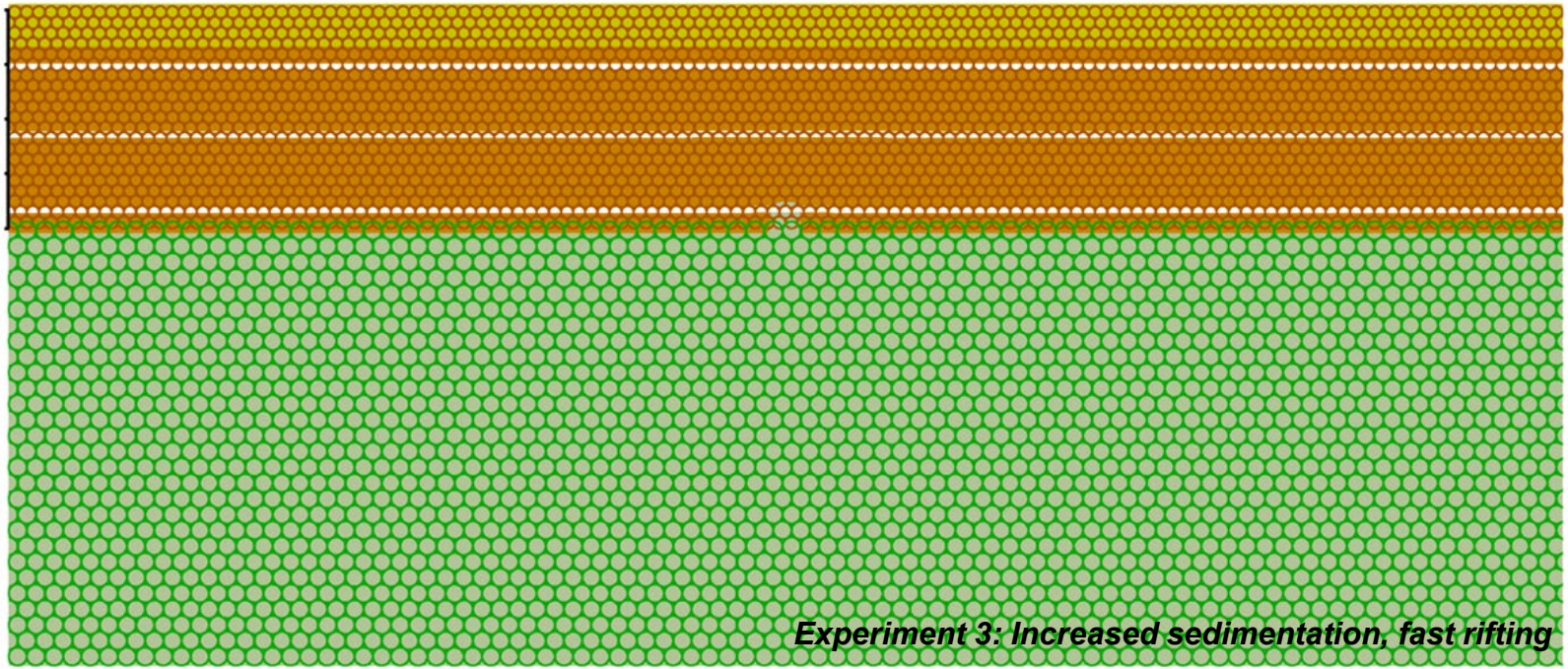
Extension alone is not observed to produce granulite facies metamorphism; an additional heat source is necessary.



Numerical Experiment Results

Aim #2 Results

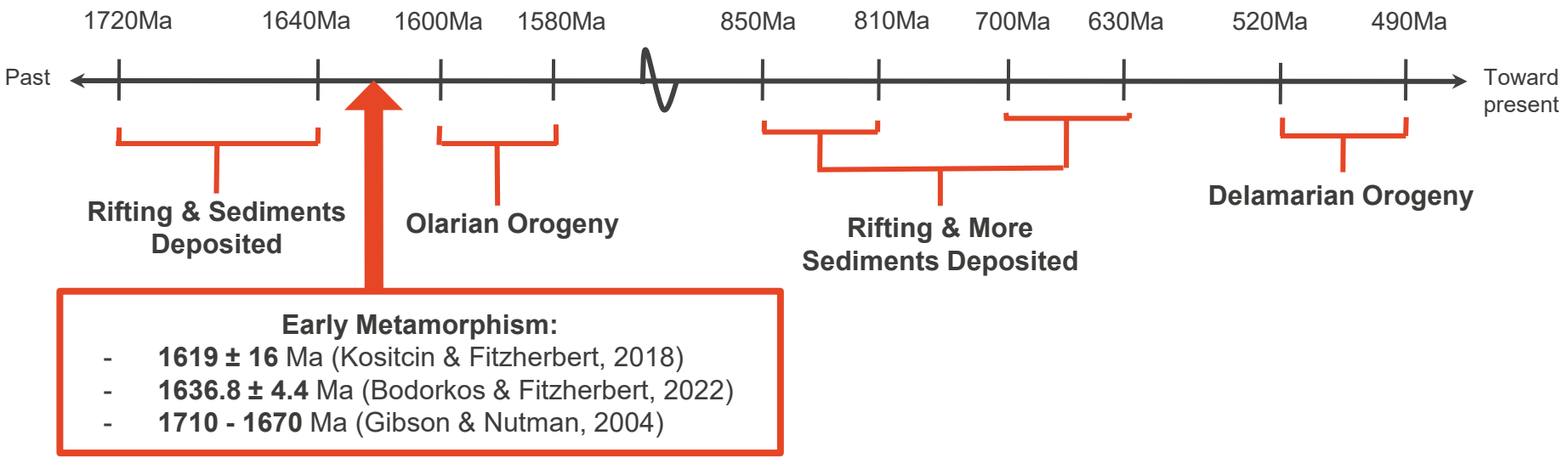
A tectonic fabric develops during extension, prior to the development of granulite facies temperatures.



Fieldwork in Broken Hill

Pursuing Aim #2

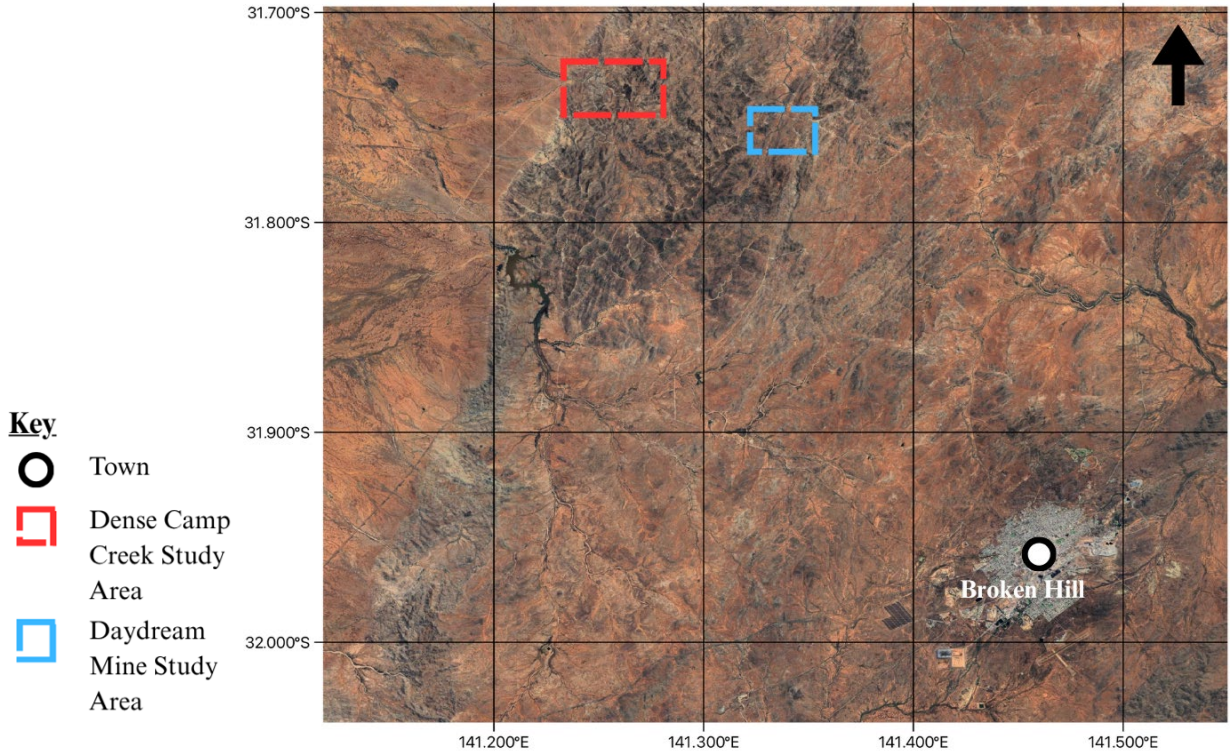
Analysing the ***relationships*** between ***tectonic fabrics*** and ***metamorphic mineral growth*** in the field and at the microscale.



Testing these insights: Fieldwork in Broken Hill

Group	Stratigraphic Units	
Paragon Group	Dalnit Bore Metasediments	
	Bijerkerno Metasediments	
	Cartwrights Creek Metasediments	
		King Gunnia Calc-Silicate Member
Sundown Group		
Broken Hill Group	**Purnamoota Sub-Group**	Hores Gneiss
		Freyers Metasediments
		Parnell Formation
	Allendale Metasediments	
		Ettlewood Calc-Silicate Member
Thackaringa Group	Himalaya Formation	
	Cues Formation	
	Lady Brassey Formation	
Thorndale Composite Gneiss		
	Cleveland Migmatite	
Curnamona Group		

*Geochronological evidence that andalusites in the **Paragon Group** grew during this metamorphic event.*



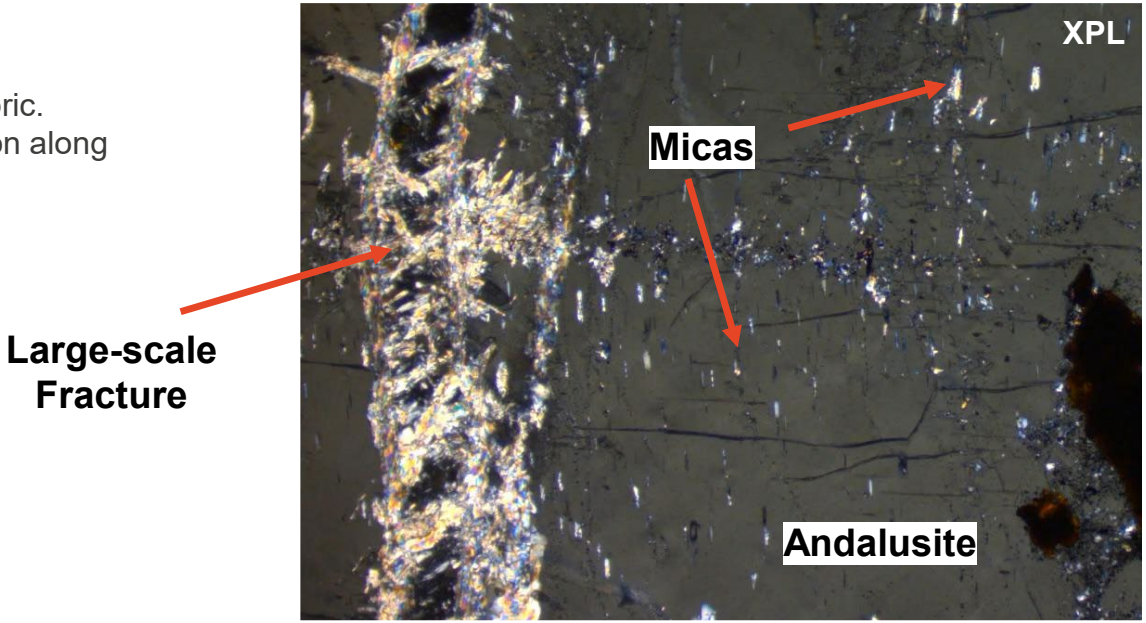
Field & Microscale Results

Aim #2 Results

Observation: At the microscale, andalusites contain aligned inclusions of white micas.

Possible Interpretations:

1. Micas represent an early fabric.
2. Micas represent retrogression along fractures.



Field & Microscale Results

Aim #2 Results

Observation: At outcrop-scale, andalusites define a fabric.

Possible Interpretations:

1. Alignment represents continued fabric development during andalusite growth.
2. Andalusites were rotated into alignment during later deformation events.

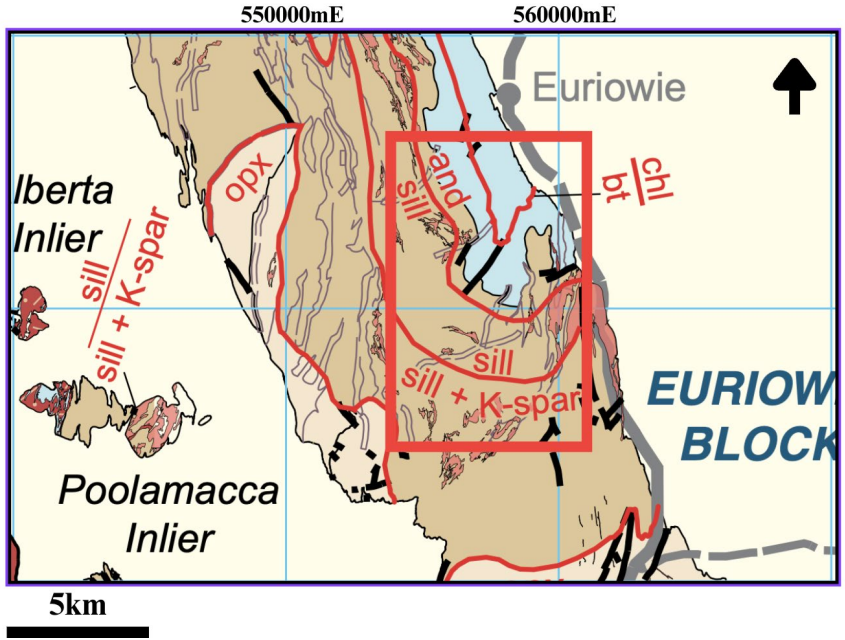
Conclusions

Aim #1: Result

Extension alone is not observed to produce granulite facies metamorphism; an additional heat source is necessary.

Aim #2: Result

A fabric develops during extension, prior to the development of granulite facies temperatures. Field and microscale evidence inconclusive.



Future Work: 3D models, increased model complexity, additional field locations of interest…