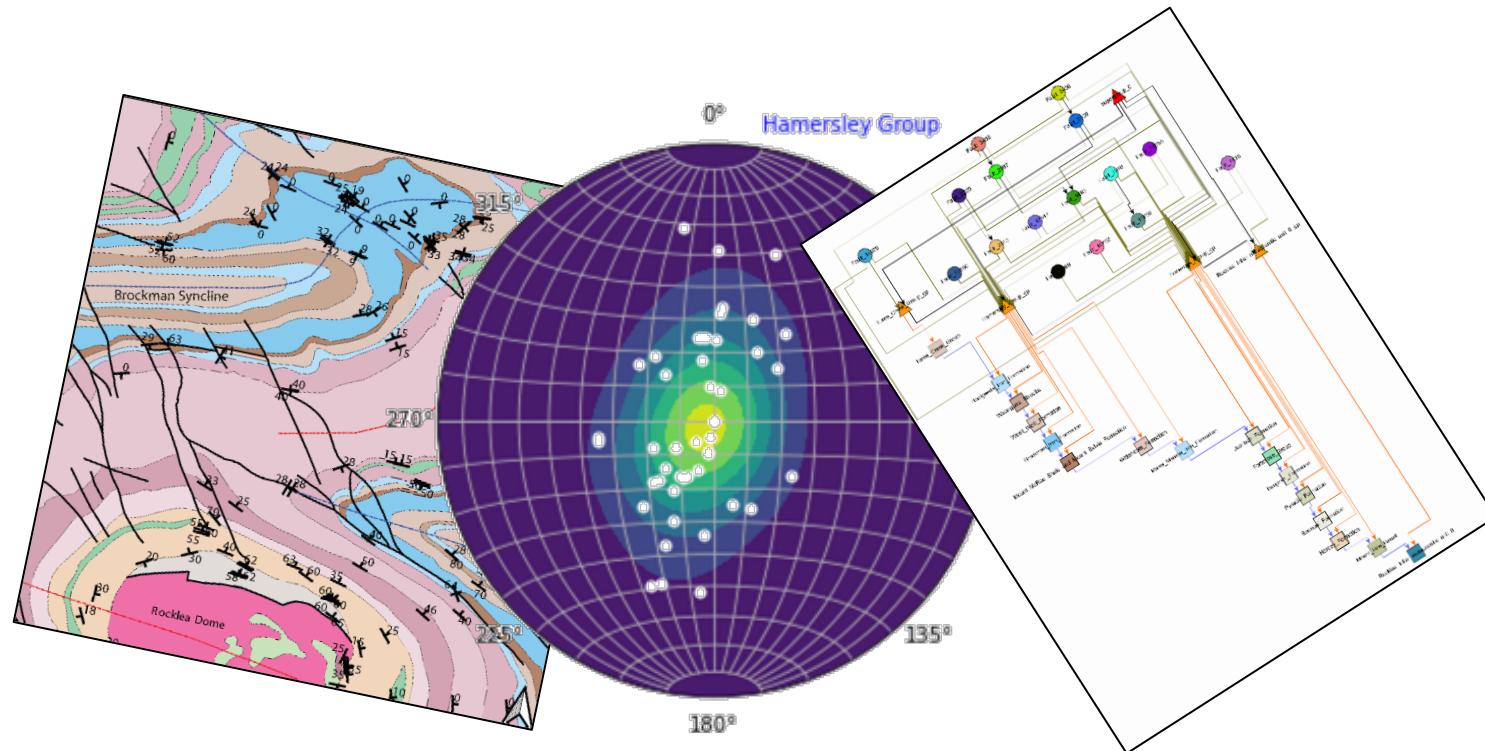


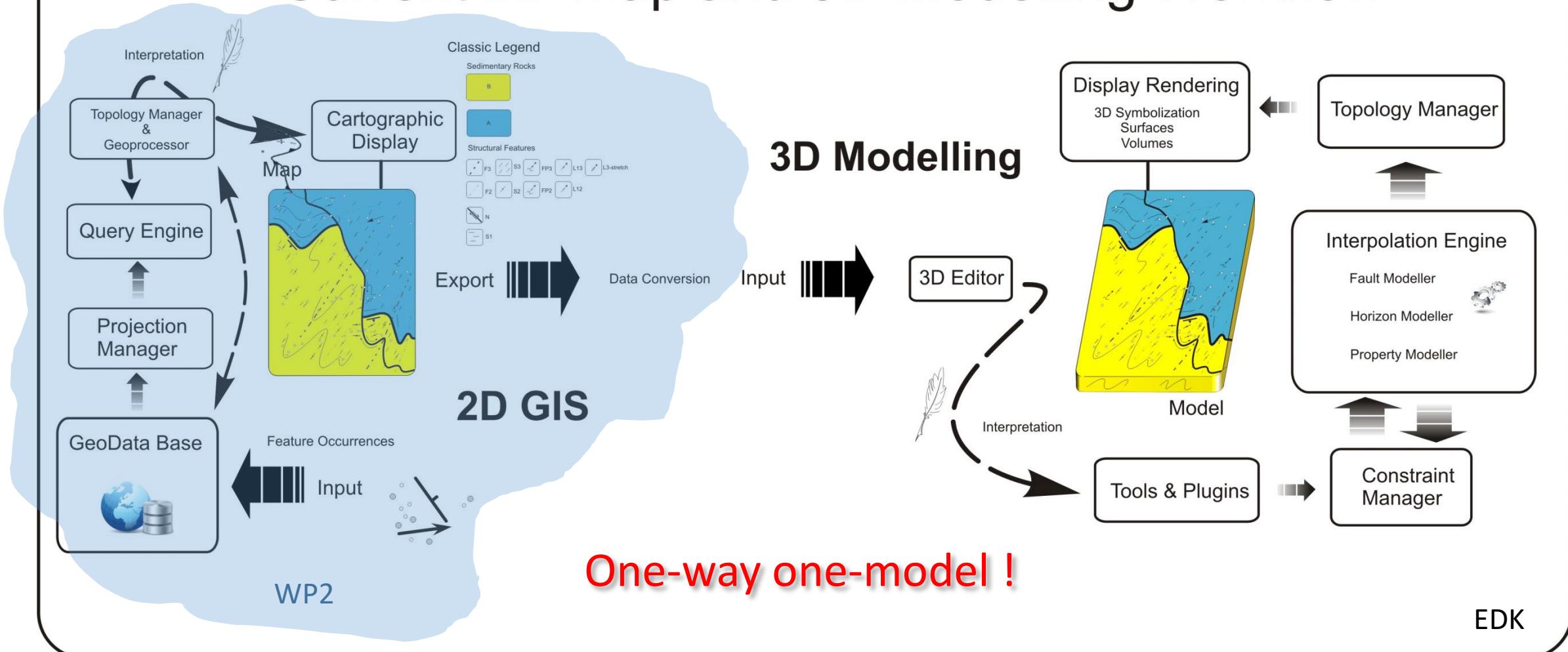
WP2: Map deconstruction aids 3D model construction *Loop*



Mark Jessell, Vitaliy Ogarko, Mark Lindsay, Ranee Joshi, Lachlan Grose, Laurent Ailleres, Michel Nzikou, Guillaume Pirot



Current 2D Map and 3D Modelling Workflow



WP2 will provide Loop with the ability to directly access online and offline geoscientific datasets, which it will then process to extract the data required for 3D Geological Modelling. This includes re-projection, upscaling, information extraction and exporting in native formats aimed at a variety of implicit 3D Geological modelling engines.

Why *map2loop*?

- Significantly reduces the time to first prototype models;
- Allows reproducible modelling from raw data, whereas current Uncertainty Quantification workflows start from model-ready inputs;
- Clearly separates the primary observations, interpretations, derived data and conceptual priors during the data reduction steps; and
- Provides a homogenous pathway to Sensitivity Analysis, Uncertainty Quantification, Multiscale Modelling and Value of Information studies

Principles:

- Accept structured data as-is
 - ✓ allows real-time modelling
- Modify on the fly
 - ✓ reproject, upscale, derive missing information, define conceptual constraints
- Iteratively define all parameters needed to build a model so that they can be front-loaded into *map2loop*
 - ✓ ensures reproducibility

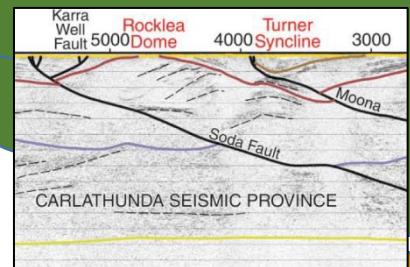
Ingredients of a 3D geological model (and sources of uncertainty)



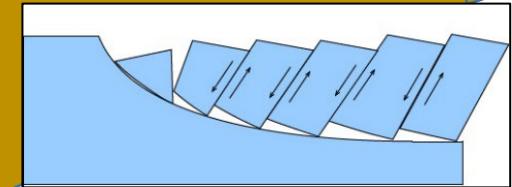
Observations



Interpretations

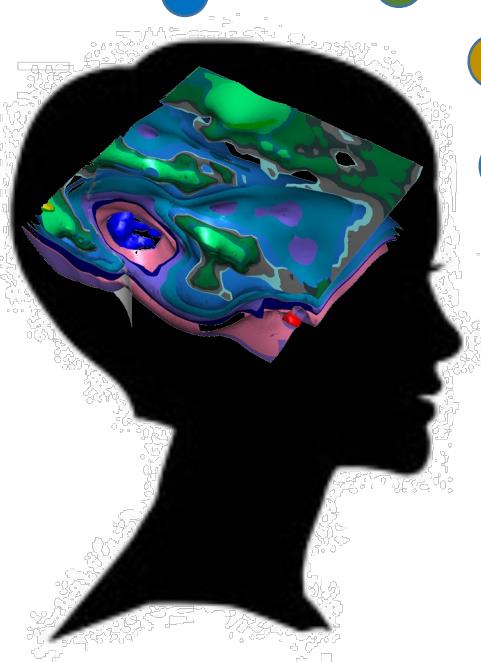


Concepts



Algorithms

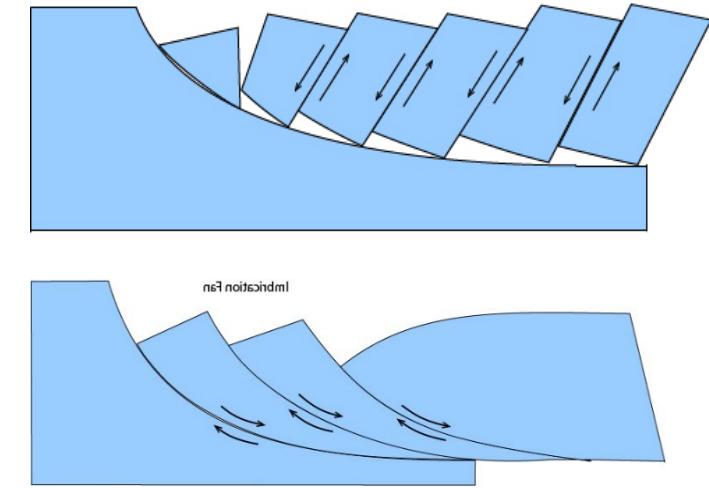
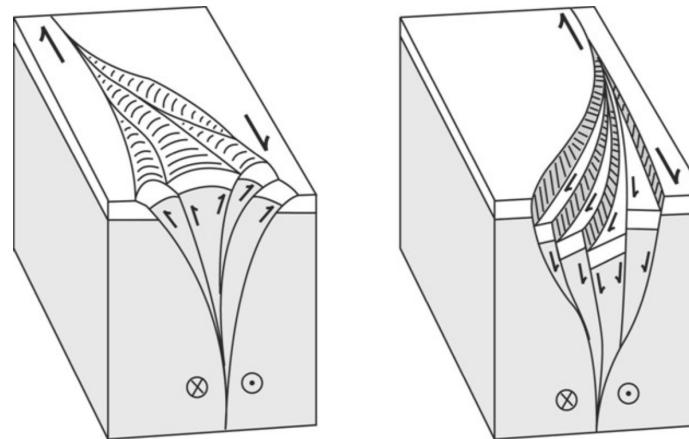
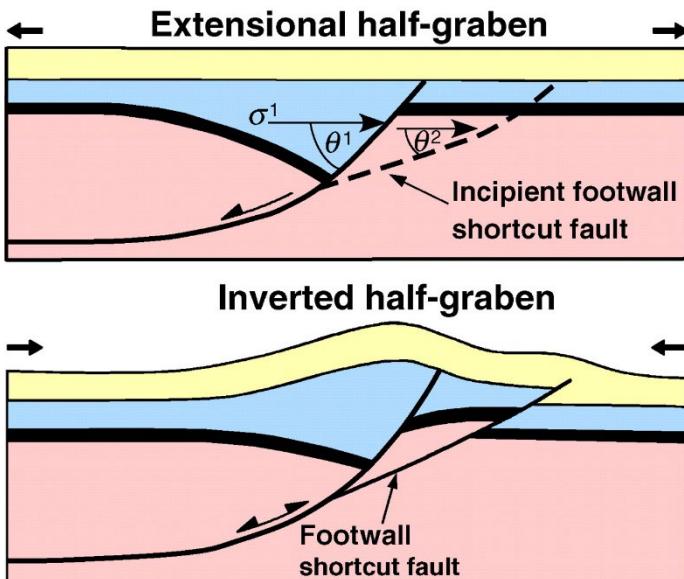
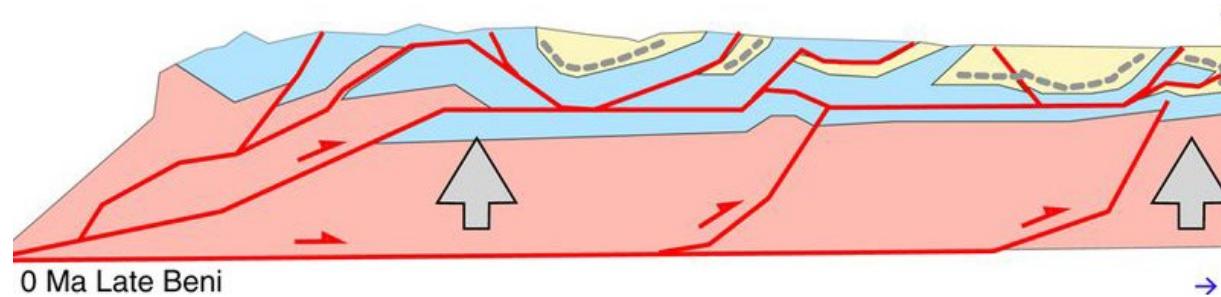
$$\varphi(r) = \sqrt{1 + (\varepsilon r)^2}$$



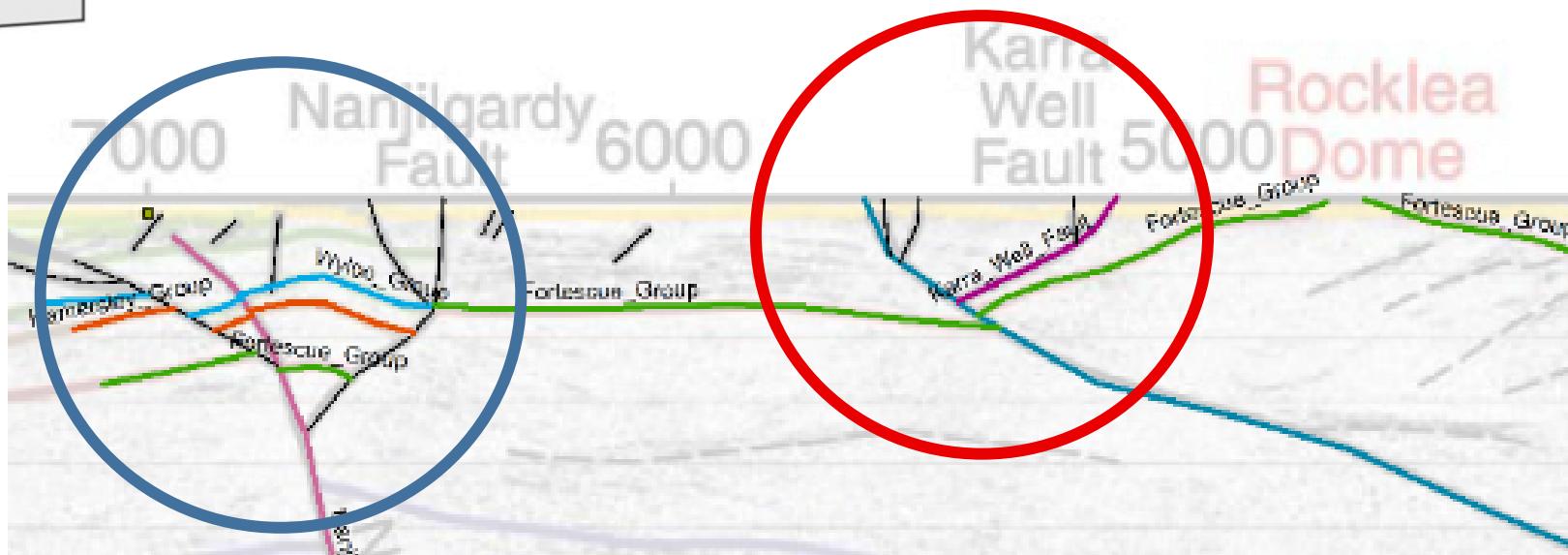
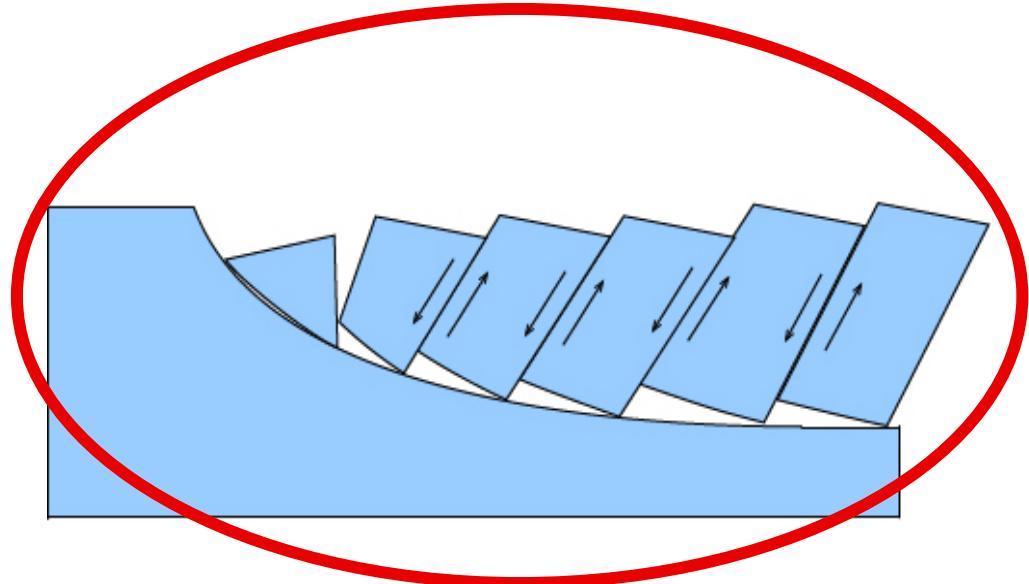
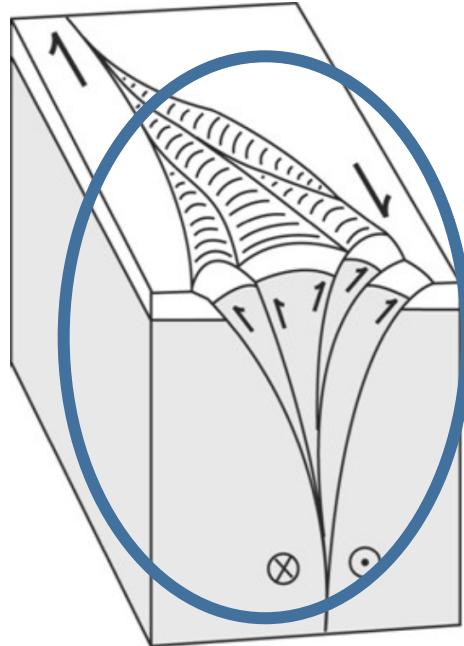


Prior concepts about region (faults)

Without limited geophysical constraints, the sub-surface geometry of faults is often ‘solved’ by applying a pre-conceived notion based on vertical, listric, flower or negative flow, fold & thrust geometries.

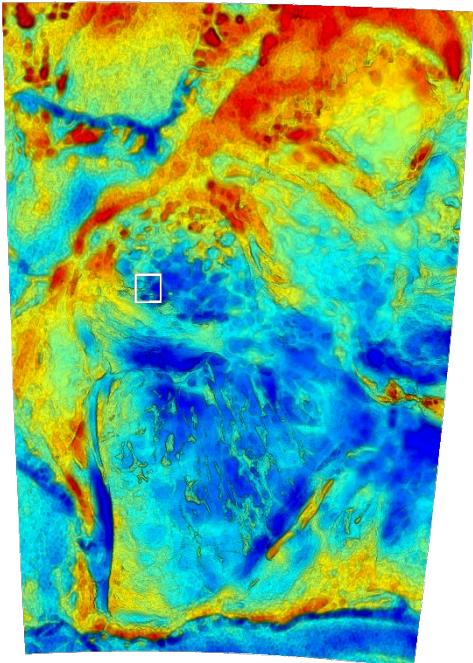


Prior concepts about region (faults)

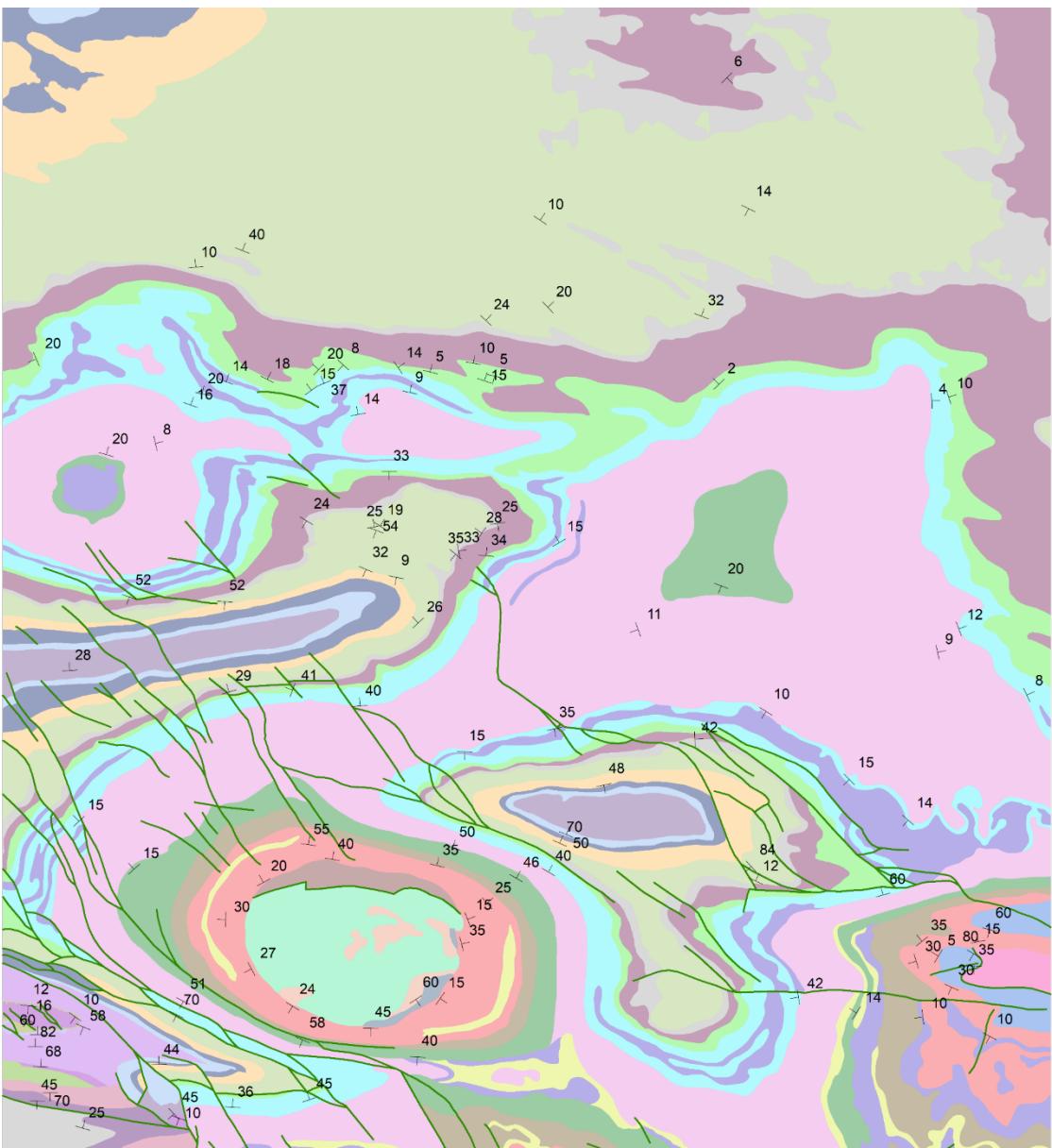


Two end-member regional 3D modelling scenarios:

1. Geological constraints come FIRST

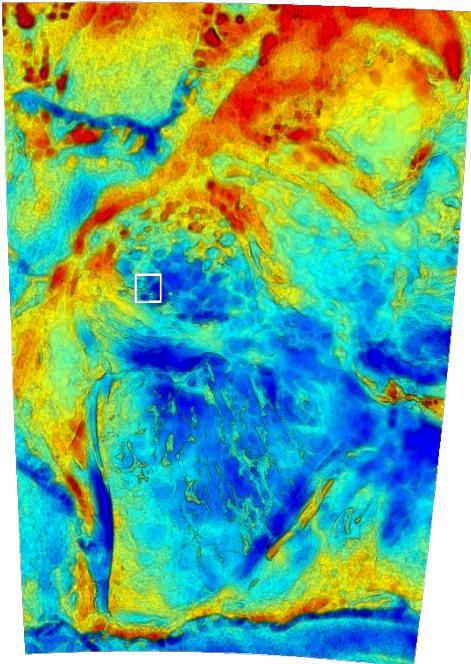


GSWA 500K
Interpreted Bedrock Geology
1 degree square

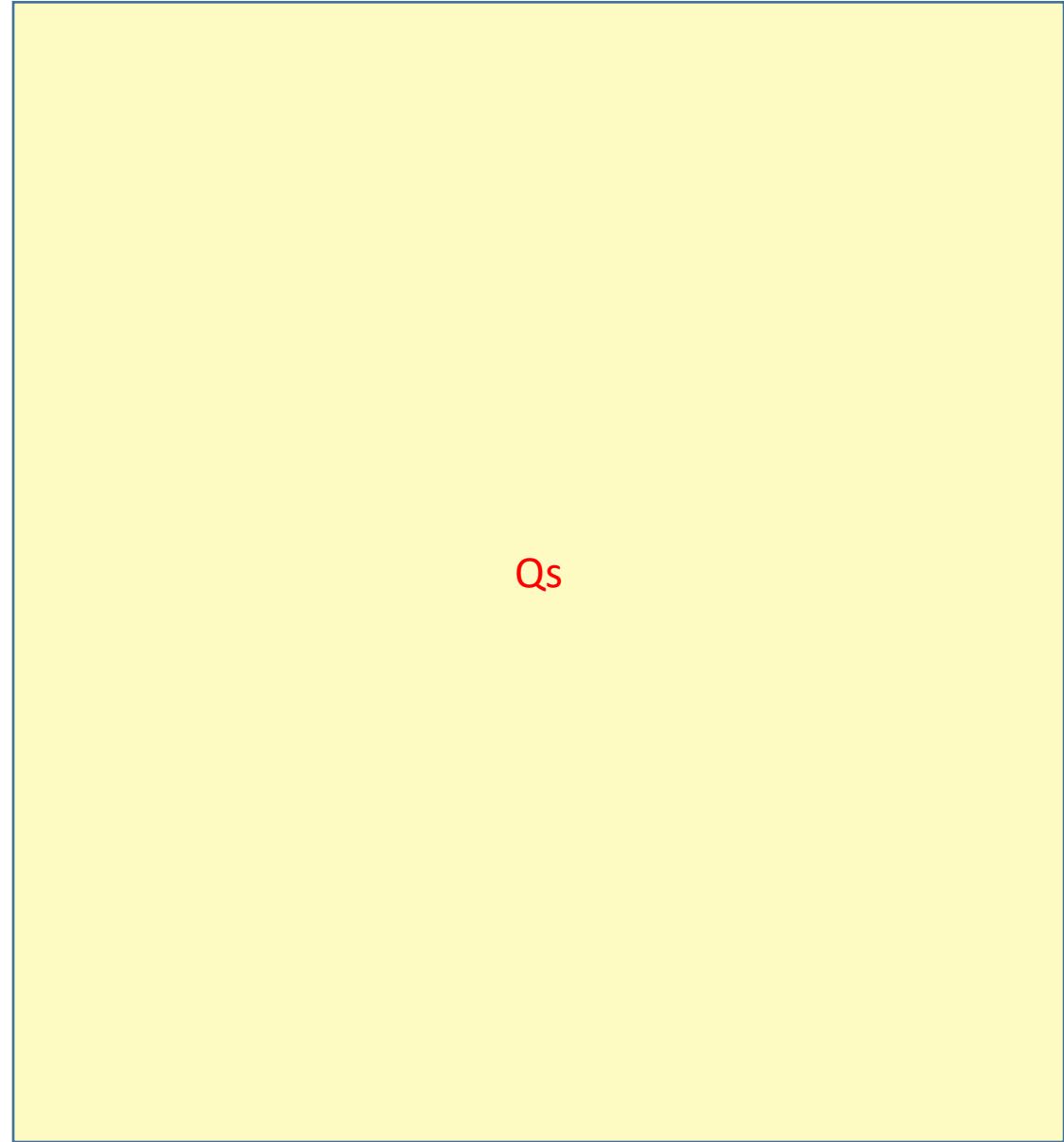


Two end-member regional 3D modelling scenarios:

1. Geological constraints come FIRST
2. Under cover, so geophysics is FIRST constraint



GSWA 500K IBG



Loop Information Manager

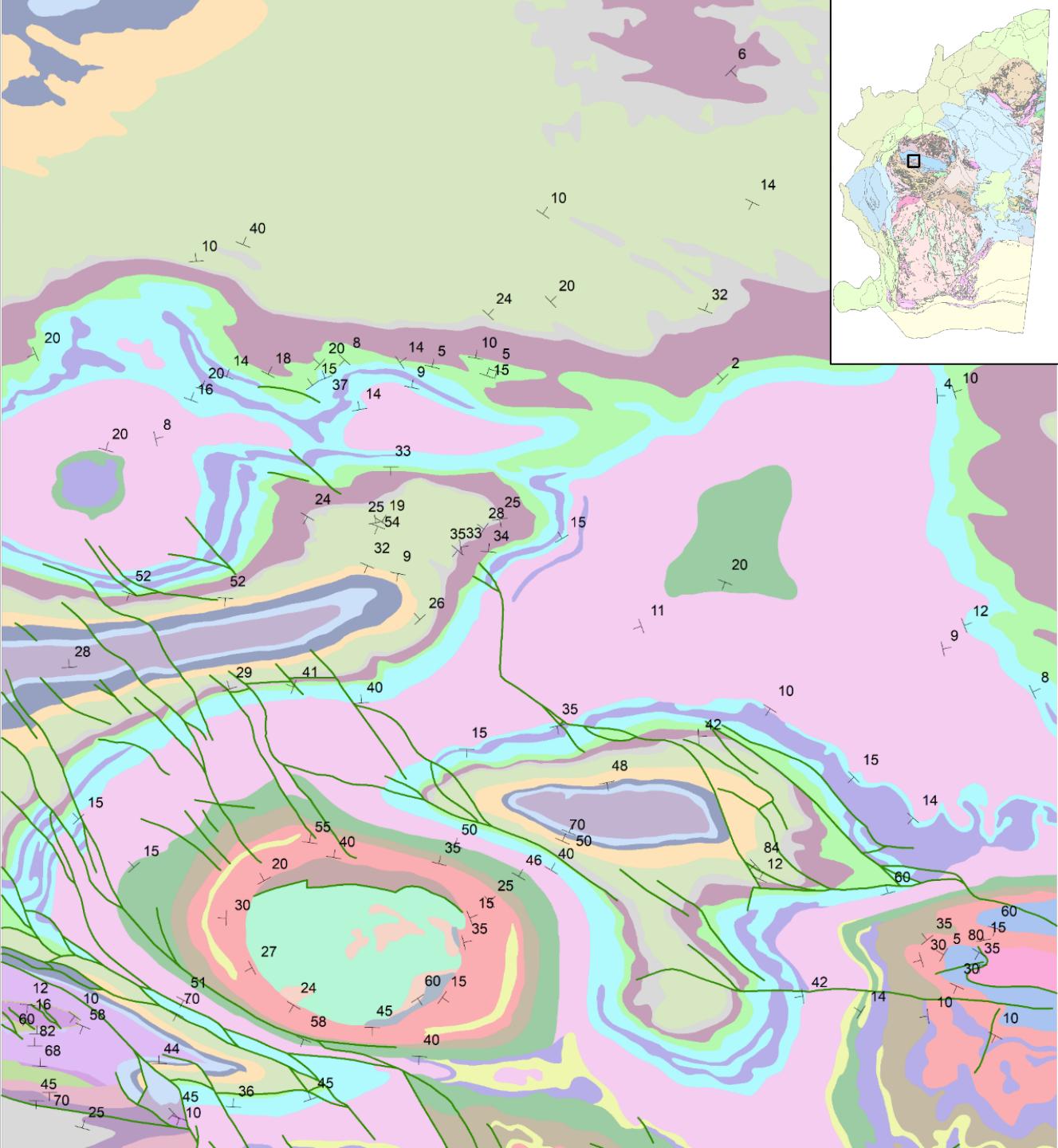
map2loop

3 layers available via WFS

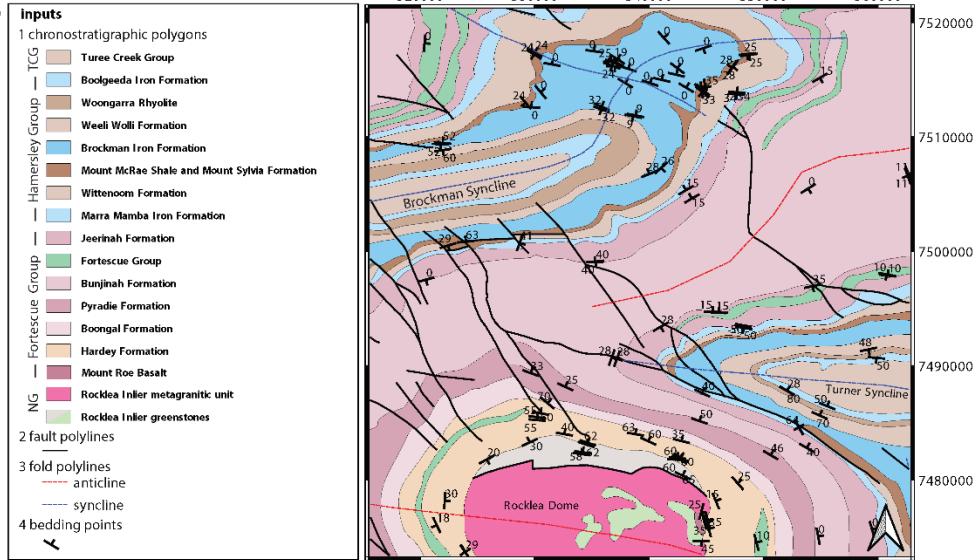
at geo.loop-gis.org/geoserver

- Geology polygons (GSWA 500k IGB)
- Fault polylines (surface trace, state)
- Structural points (bedding, local area)

DTM online from GA



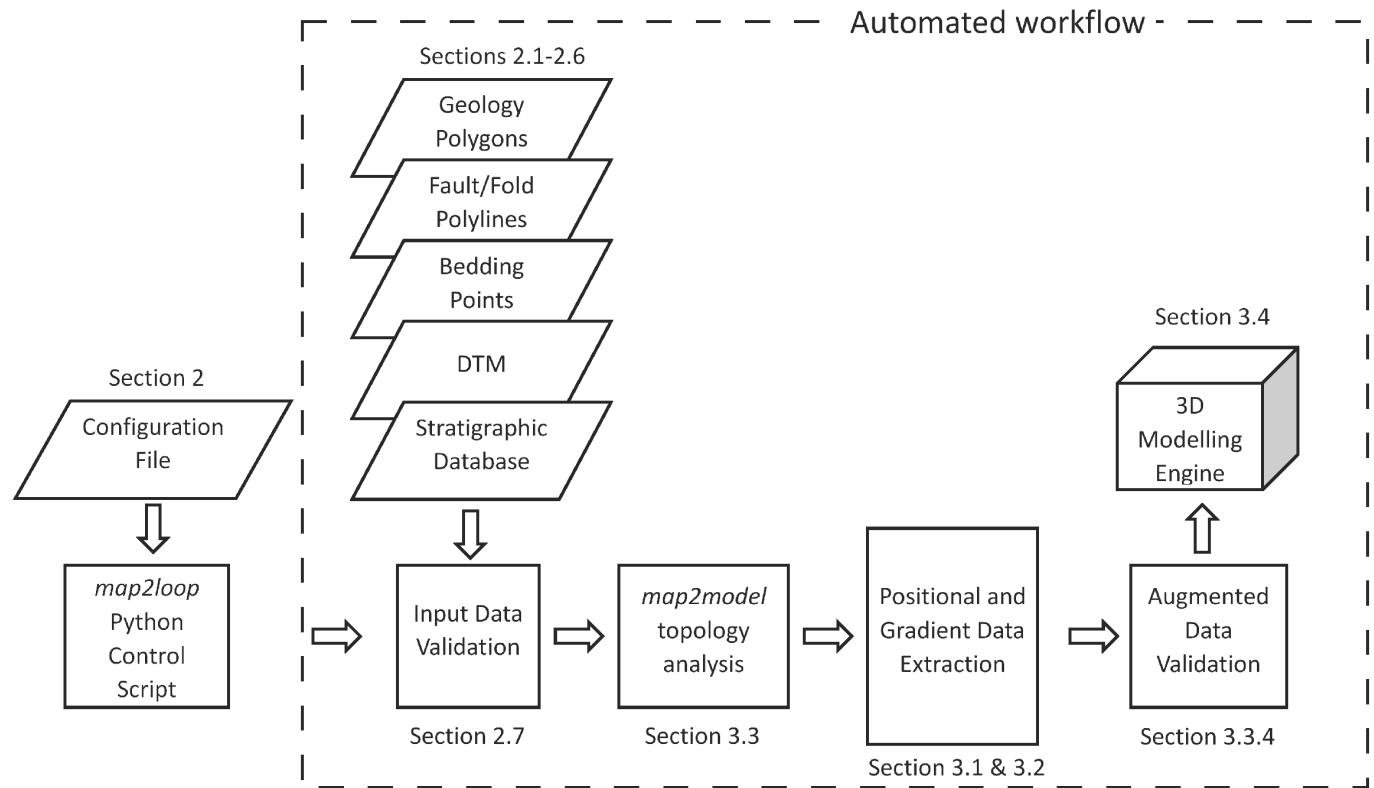
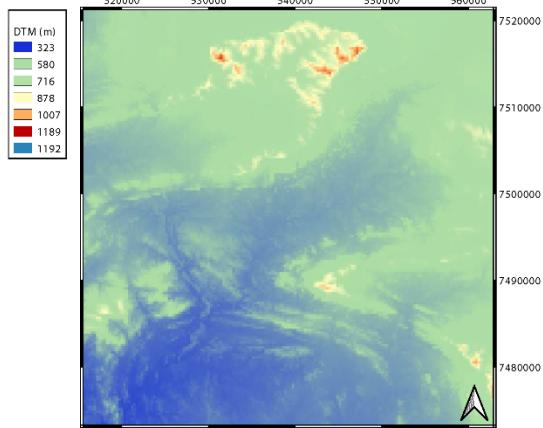
(a)

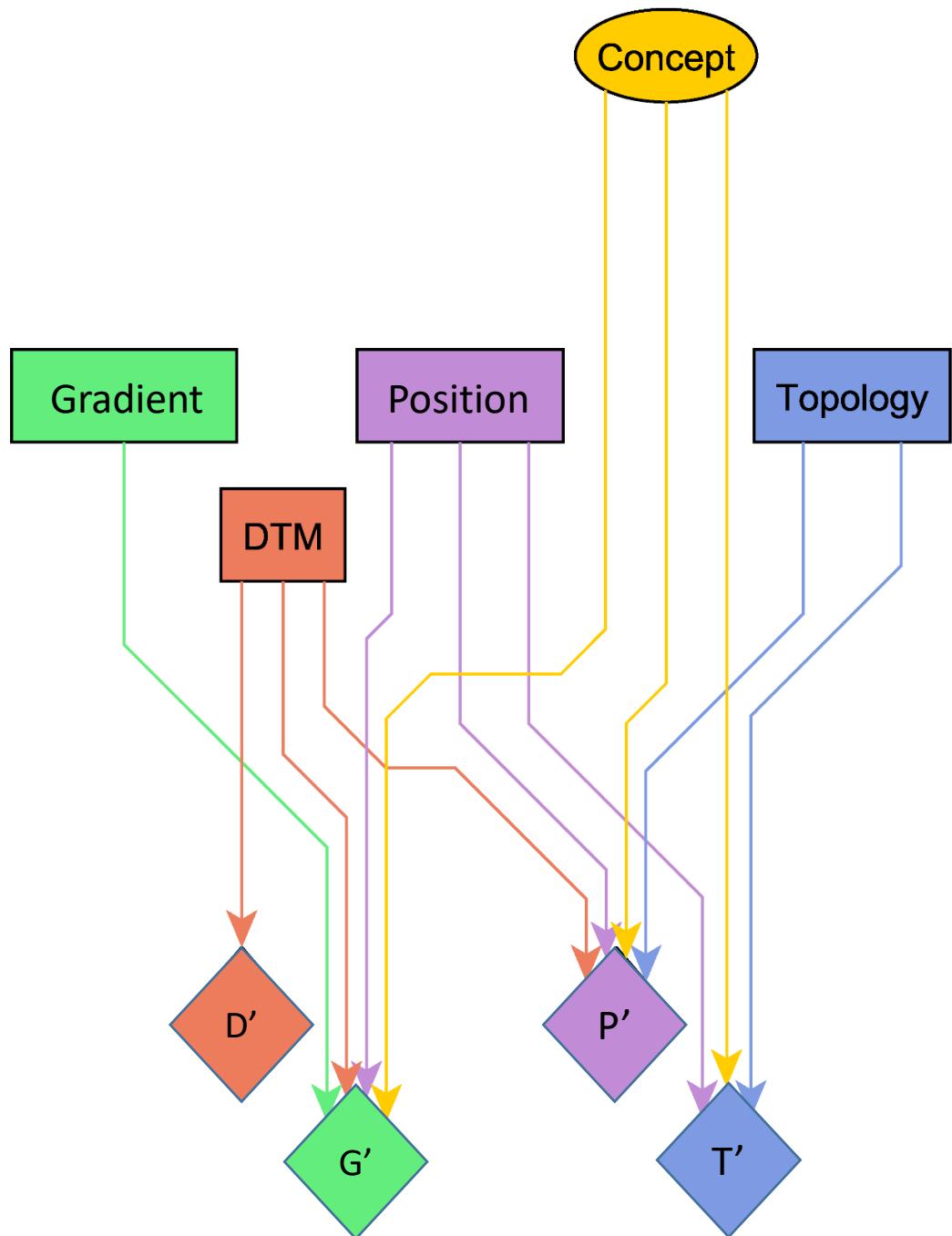


(b) Stratigraphic (overlies ->) Relationships

Turee Creek Group -> Booleeda Iron Formation
 Wittenoom Formation -> Marra Mamba Iron Formation
 Marra Mamba Iron Formation -> Jeerinah Formation
 Jeerinah Formation -> Bunjinah Formation
 Bunjinah Formation -> Pyradie Formation
 Pyradie Formation -> Boongal Formation
 Weeli Wollie Formation -> Brockman Iron Formation

(c) Digital Terrain Model





Concepts:

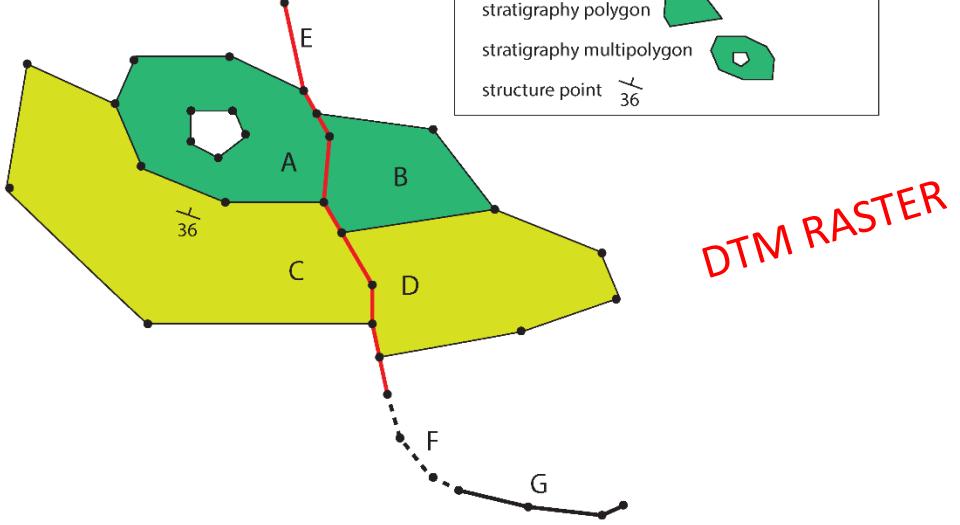
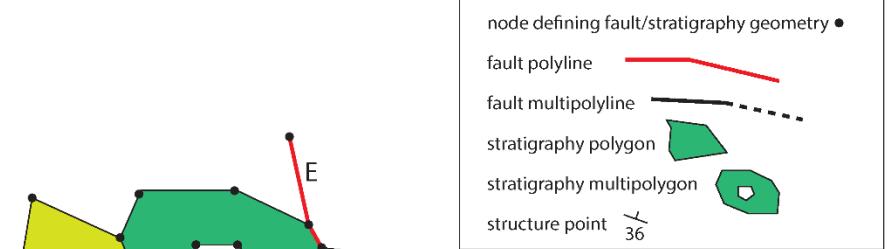
- What is the geological framework in this region?

Observations:

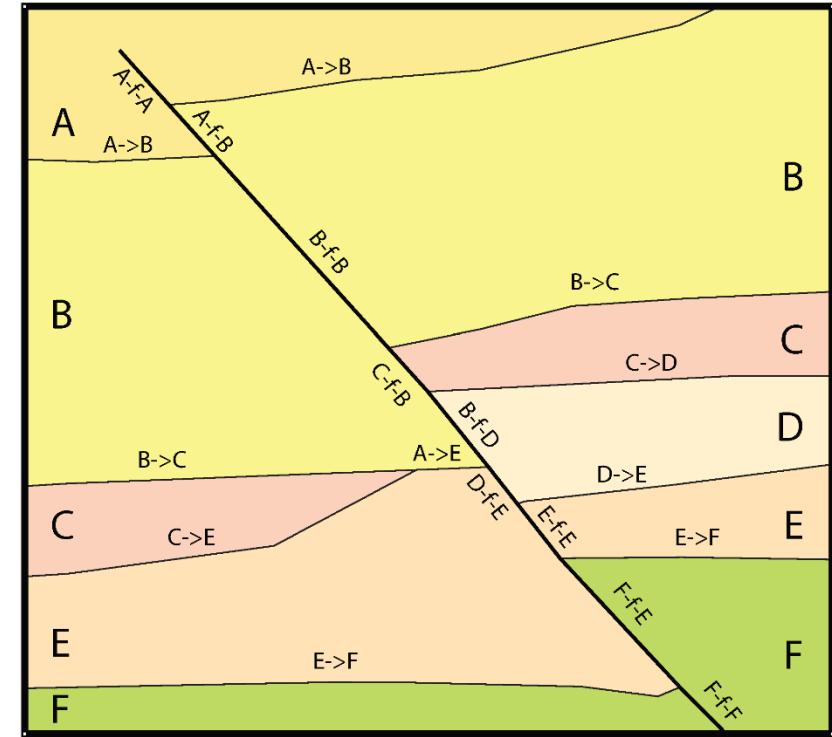
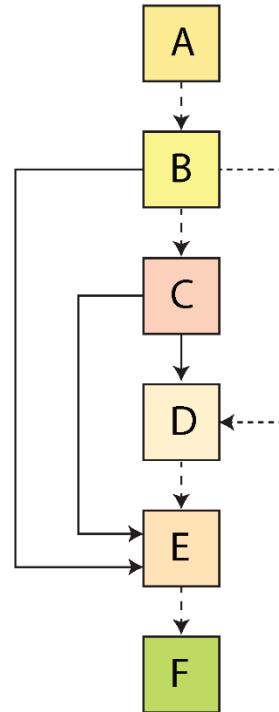
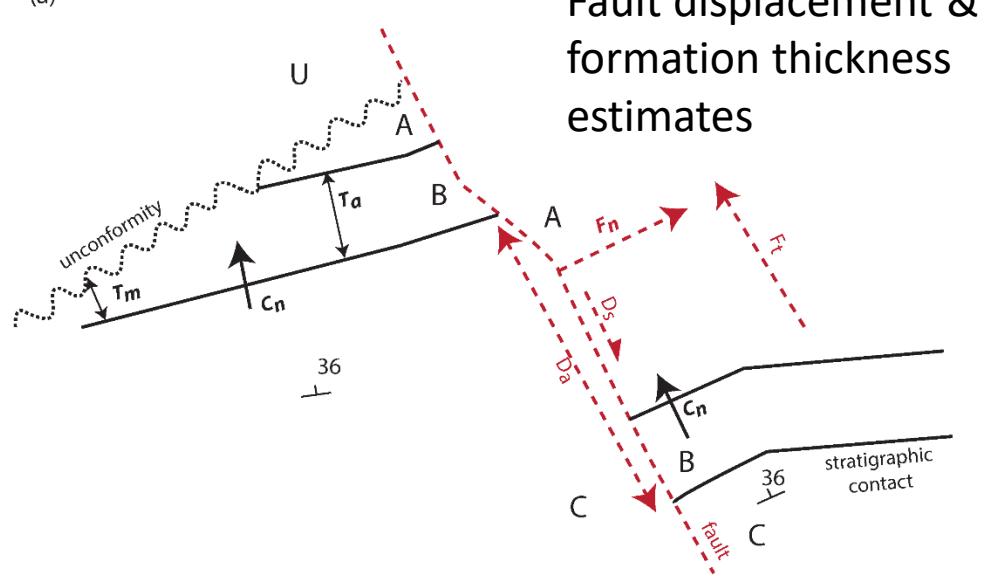
- Gradient
- Position
- Topology
- DTM

Outputs:

- Selected Observations
- Subsampled Observations
- Derived measurements



(a)



A->B : A stratigraphically overlies B

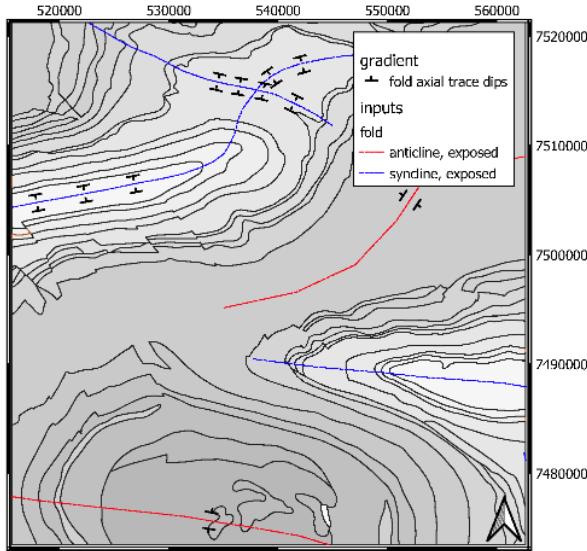
A-f-B : A is in faulted contact with B

→ stratigraphically overlies

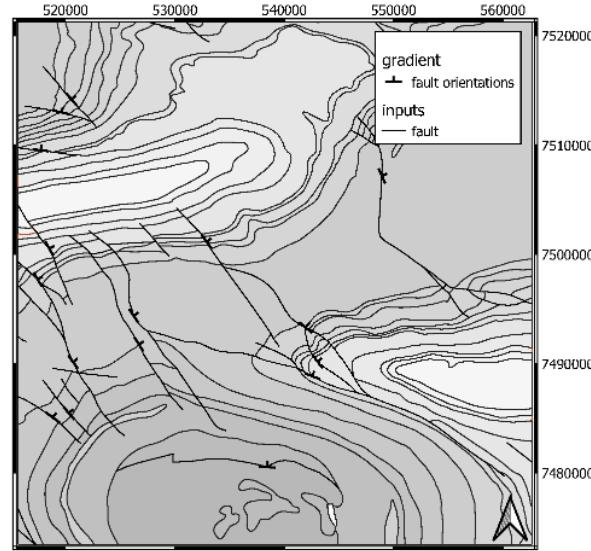
→ stratigraphically overlies and is also in faulted contact with

-----→ is in faulted contact with

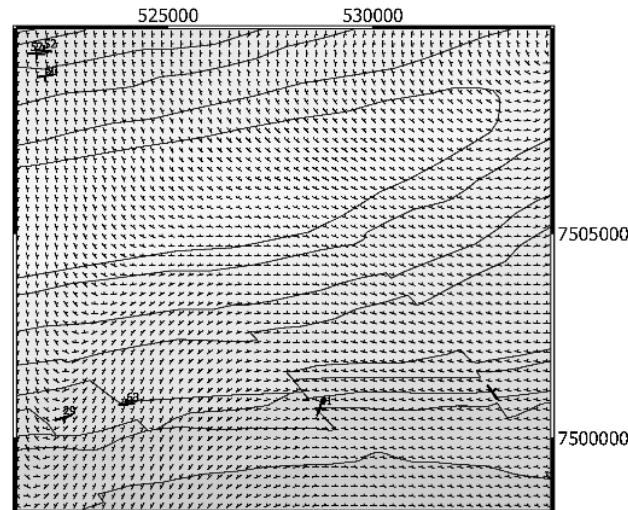
(a) fold orientations



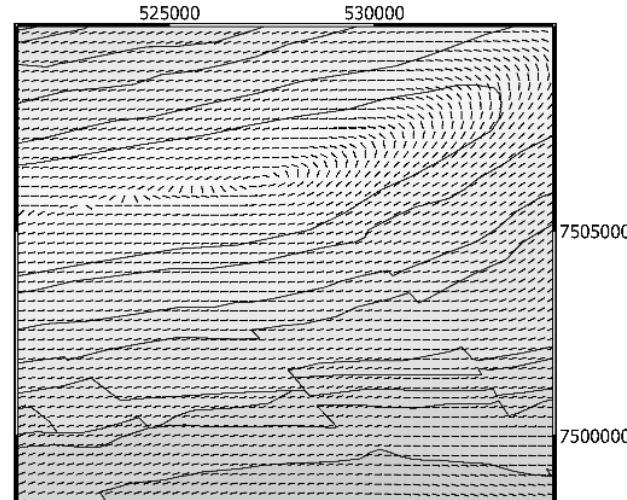
(b) fault orientations



(c) orientation field

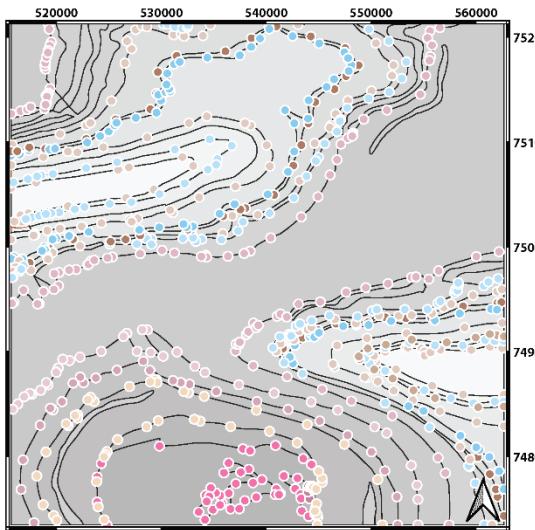


(d) contact field

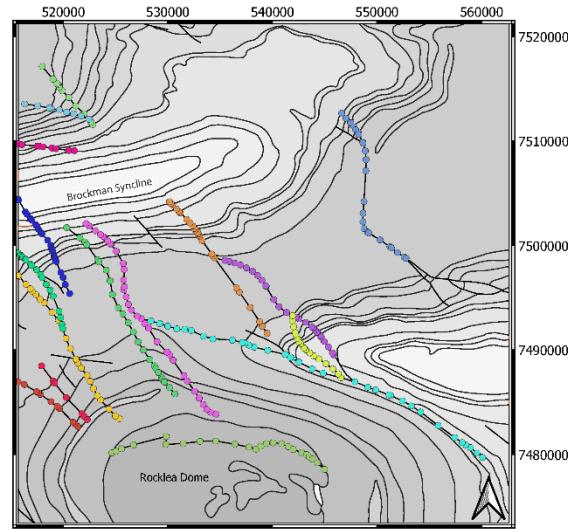


Outputs as series of cvs files & single *LoopProjectFile*

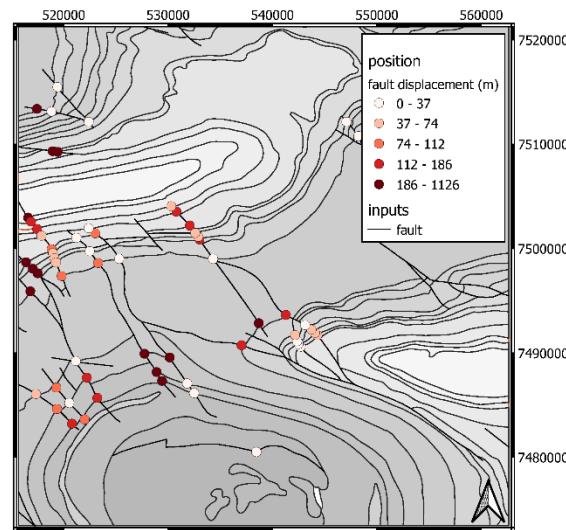
(a) contacts



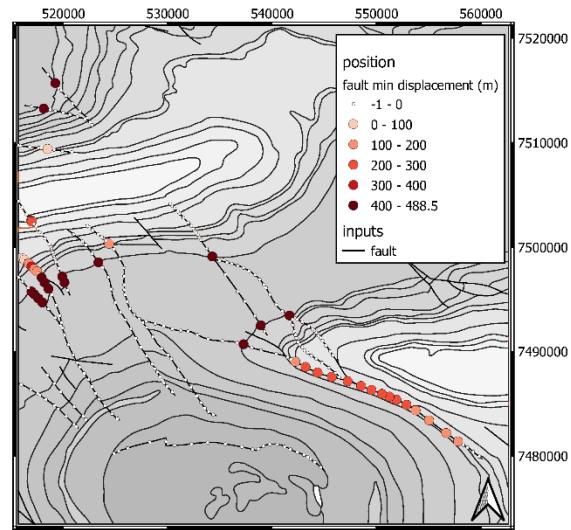
(b) faults



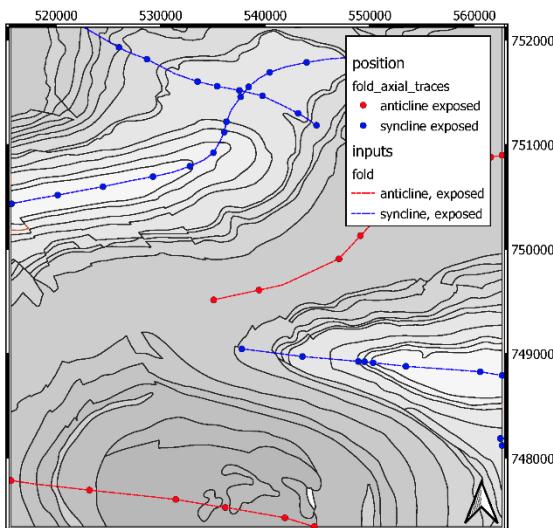
(e) fault offset



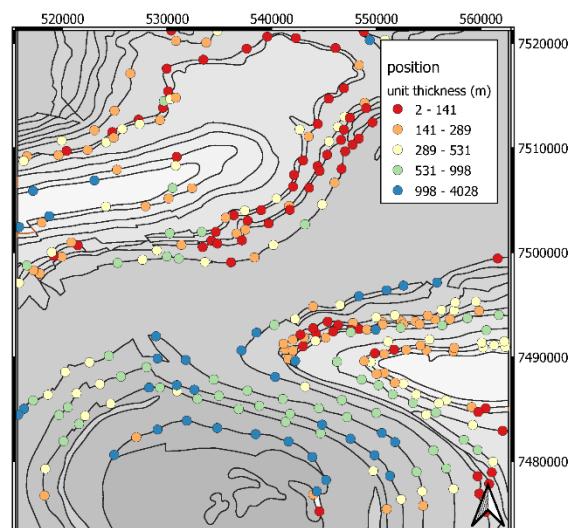
(f) fault min offset



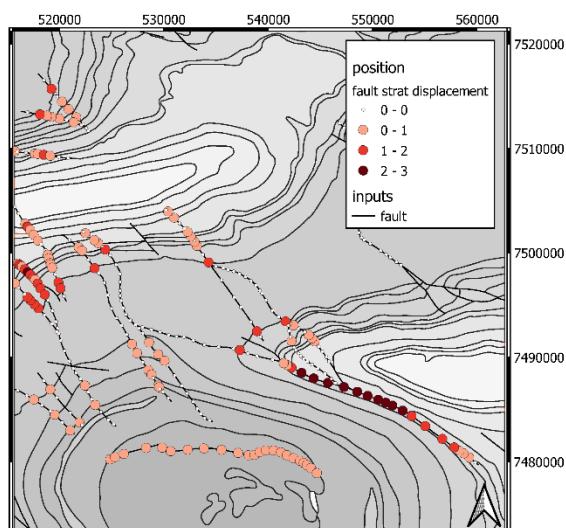
(c) folds



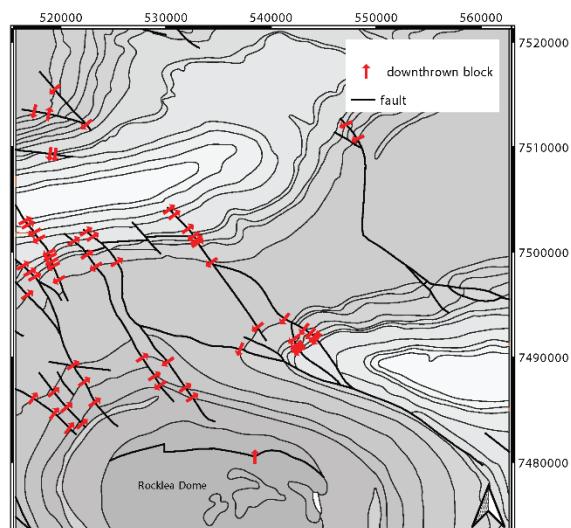
(d) unit thickness

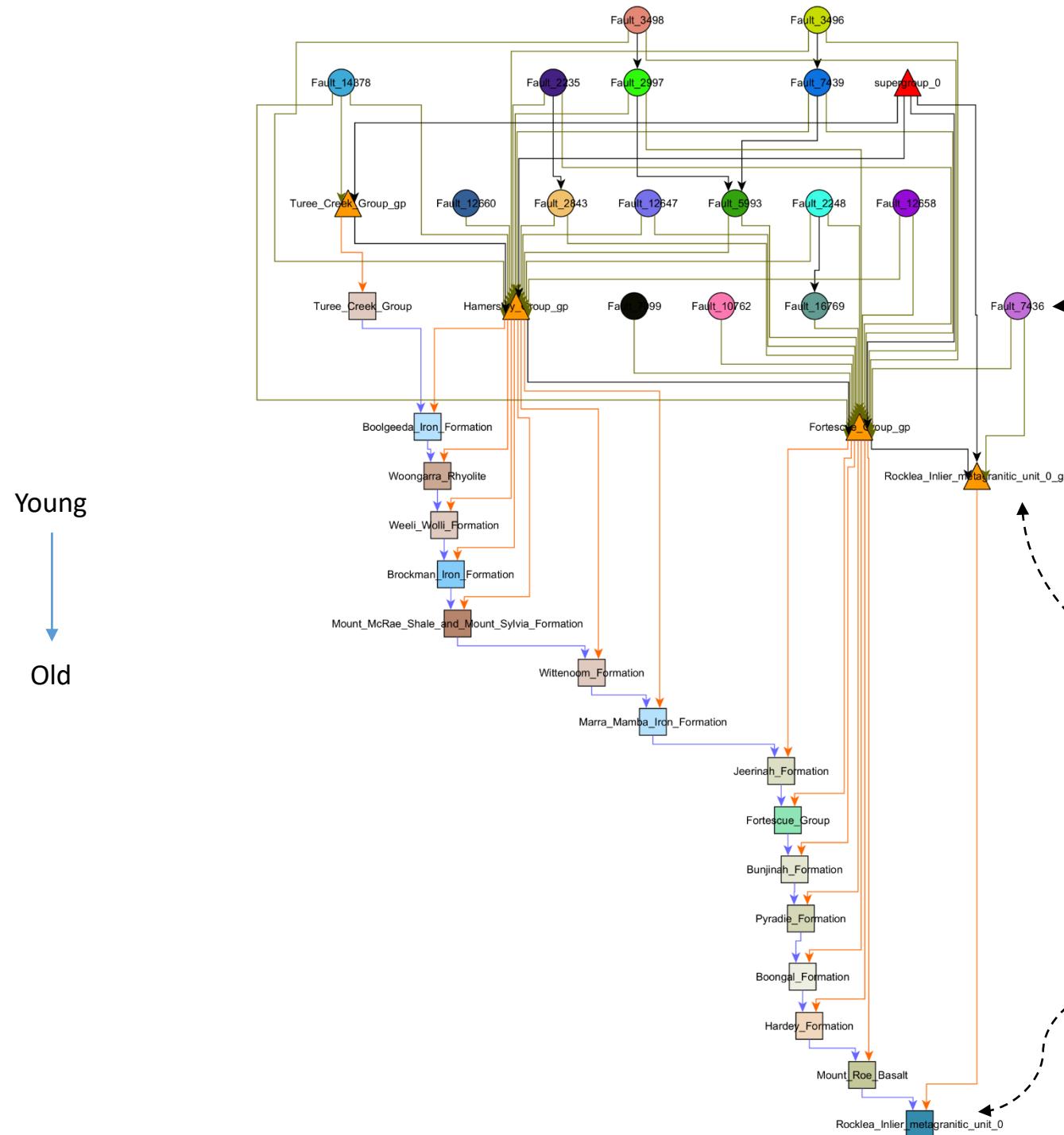


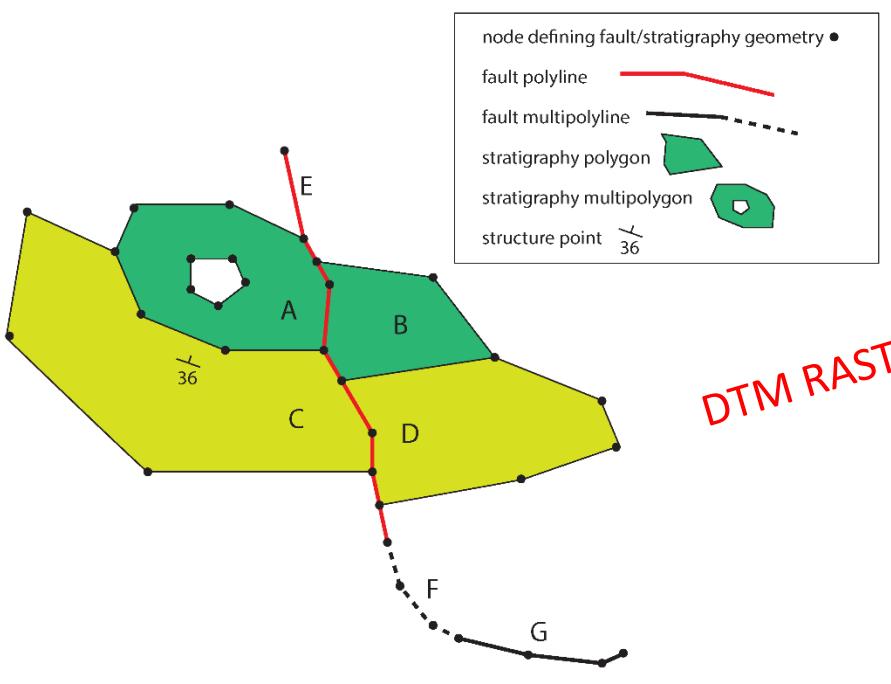
(g) fault strat offset



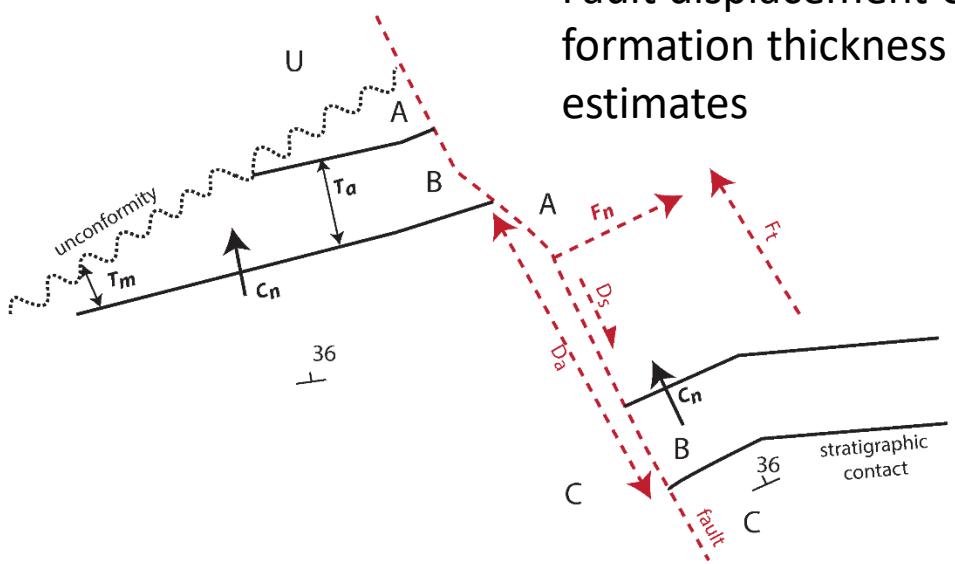
(h) downthrow



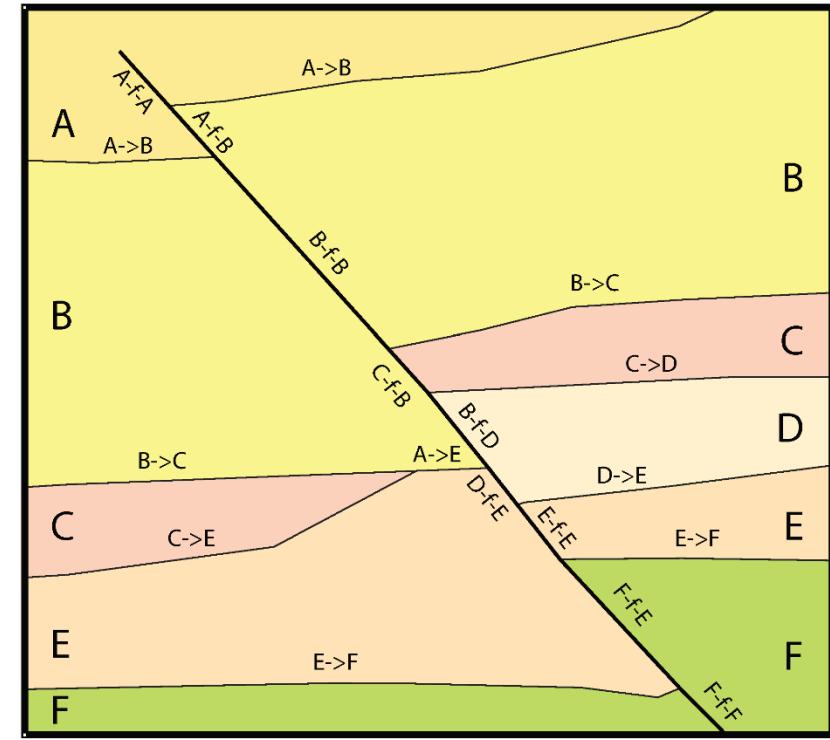
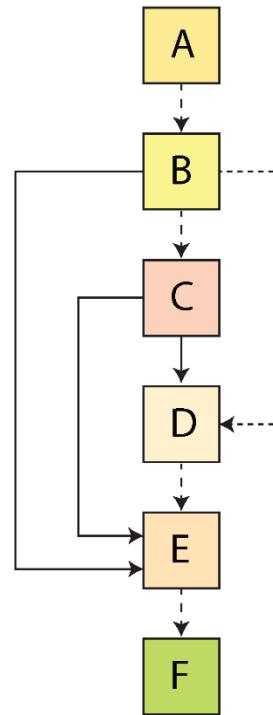
**Faults****Groups****Formations**



(a)



Fault displacement & formation thickness estimates



A->B : A stratigraphically overlies B

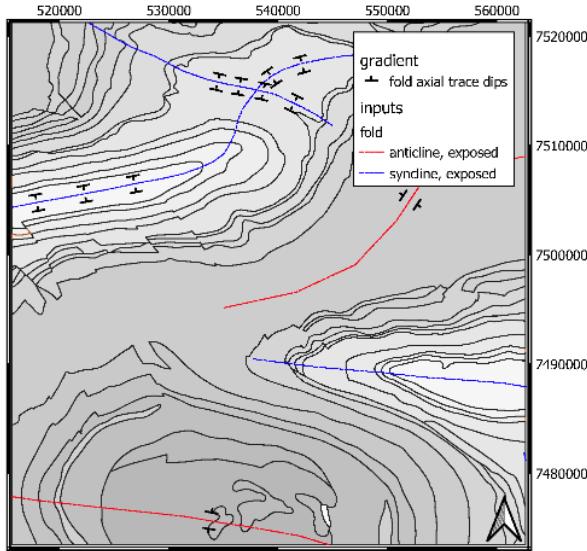
A-f-B : A is in faulted contact with B

→ stratigraphically overlies

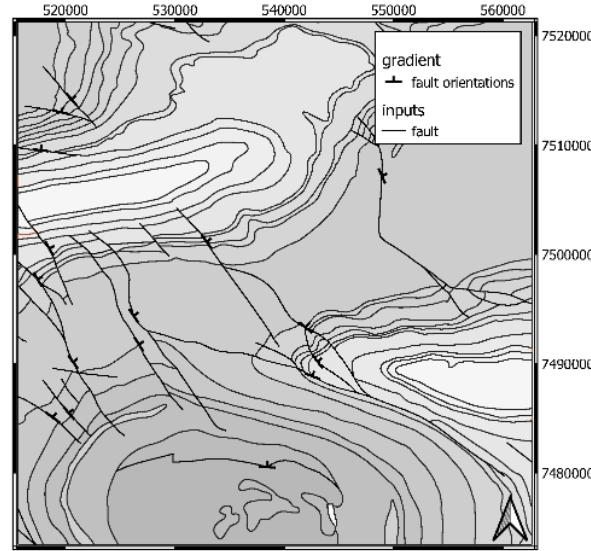
- - - - → stratigraphically overlies and is also in faulted contact with

-----> is in faulted contact with

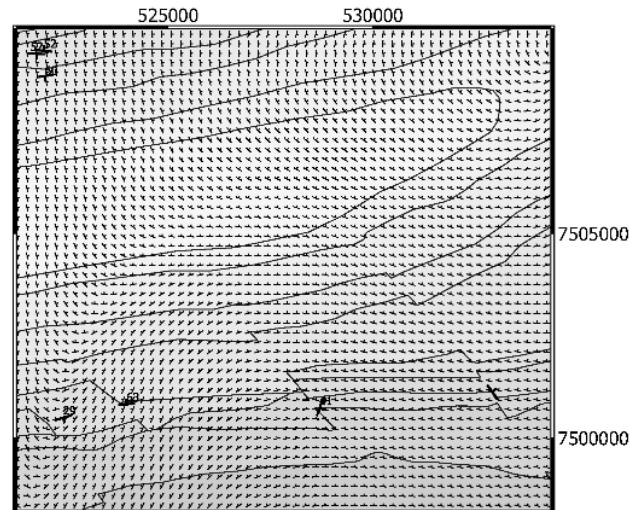
(a) fold orientations



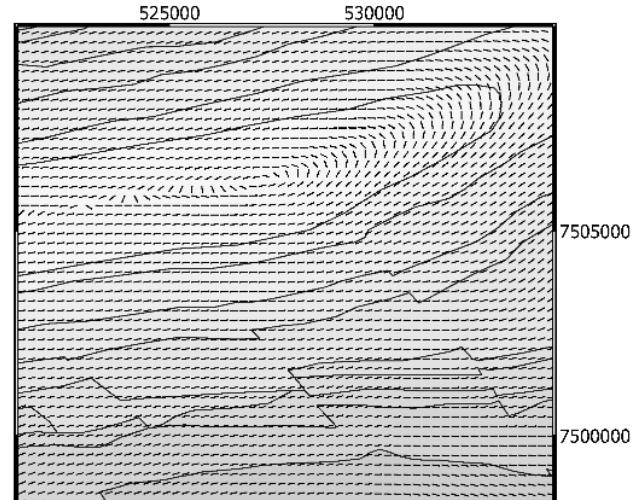
(b) fault orientations



(c) orientation field

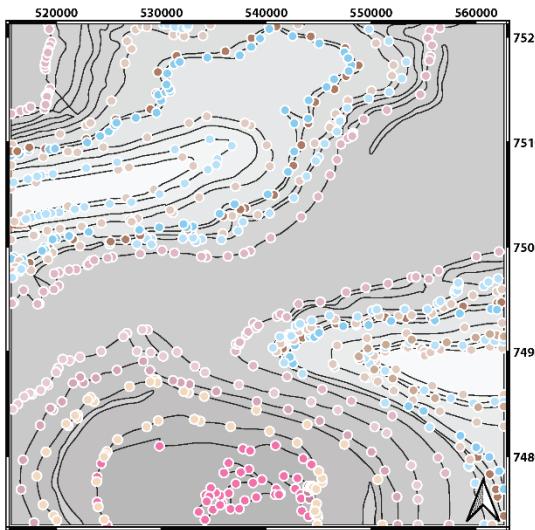


(d) contact field

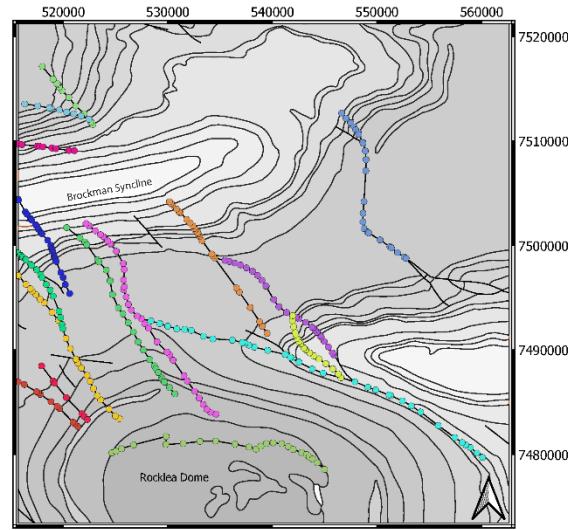


Outputs as series of cvs files & single *LoopProjectFile*

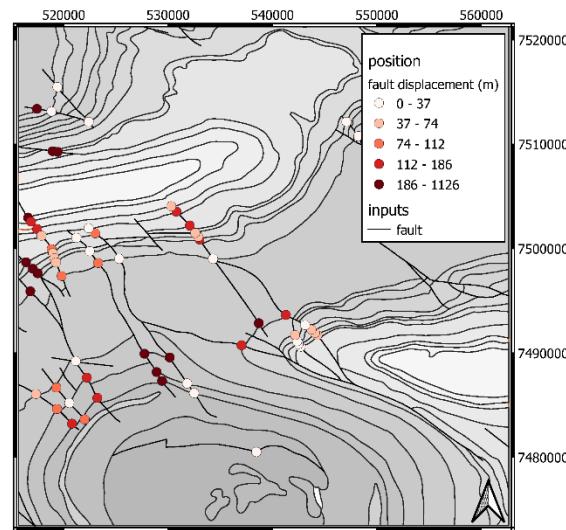
(a) contacts



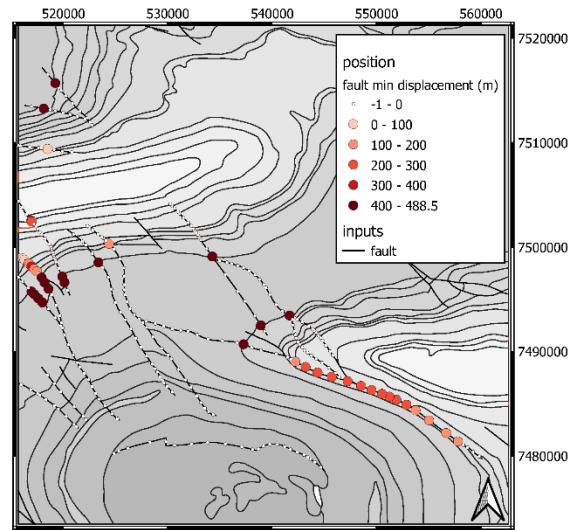
(b) faults



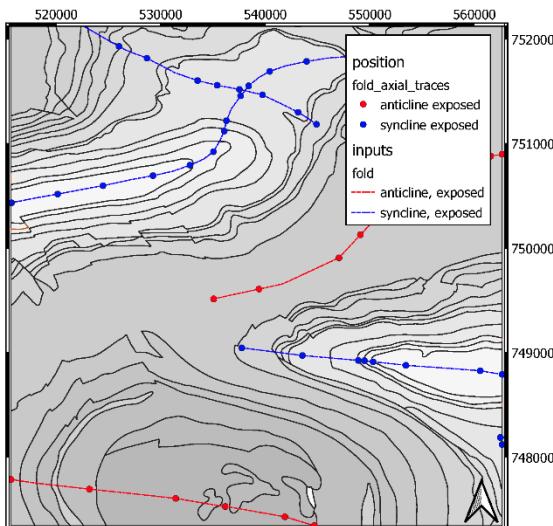
(e) fault offset



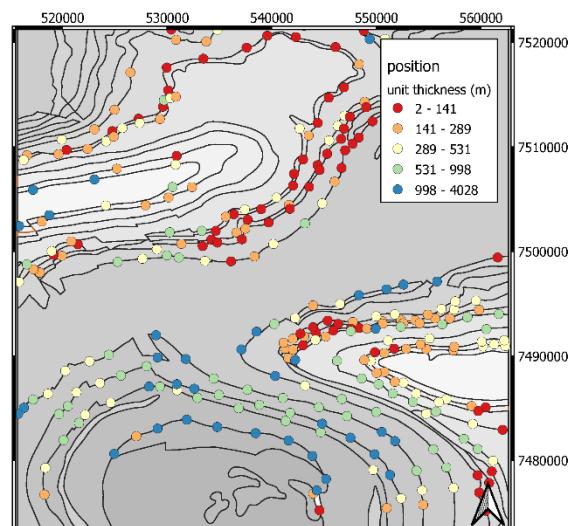
(f) fault min offset



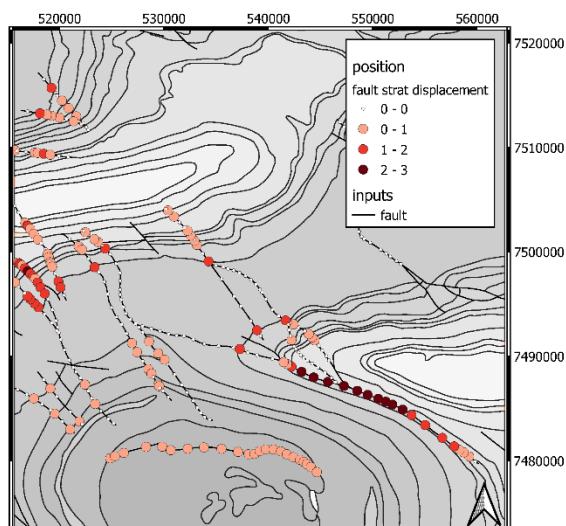
(c) folds



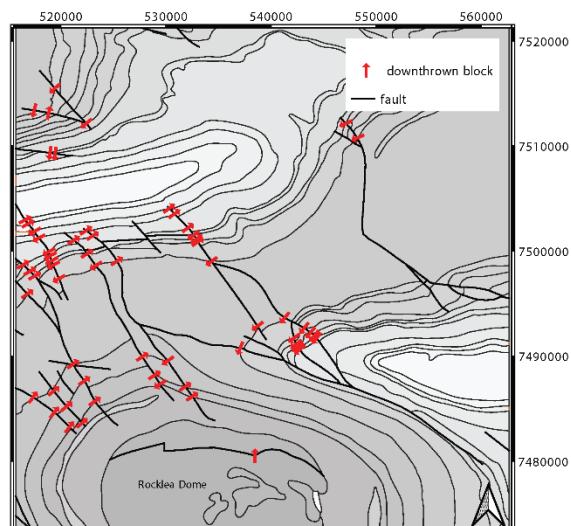
(d) unit thickness

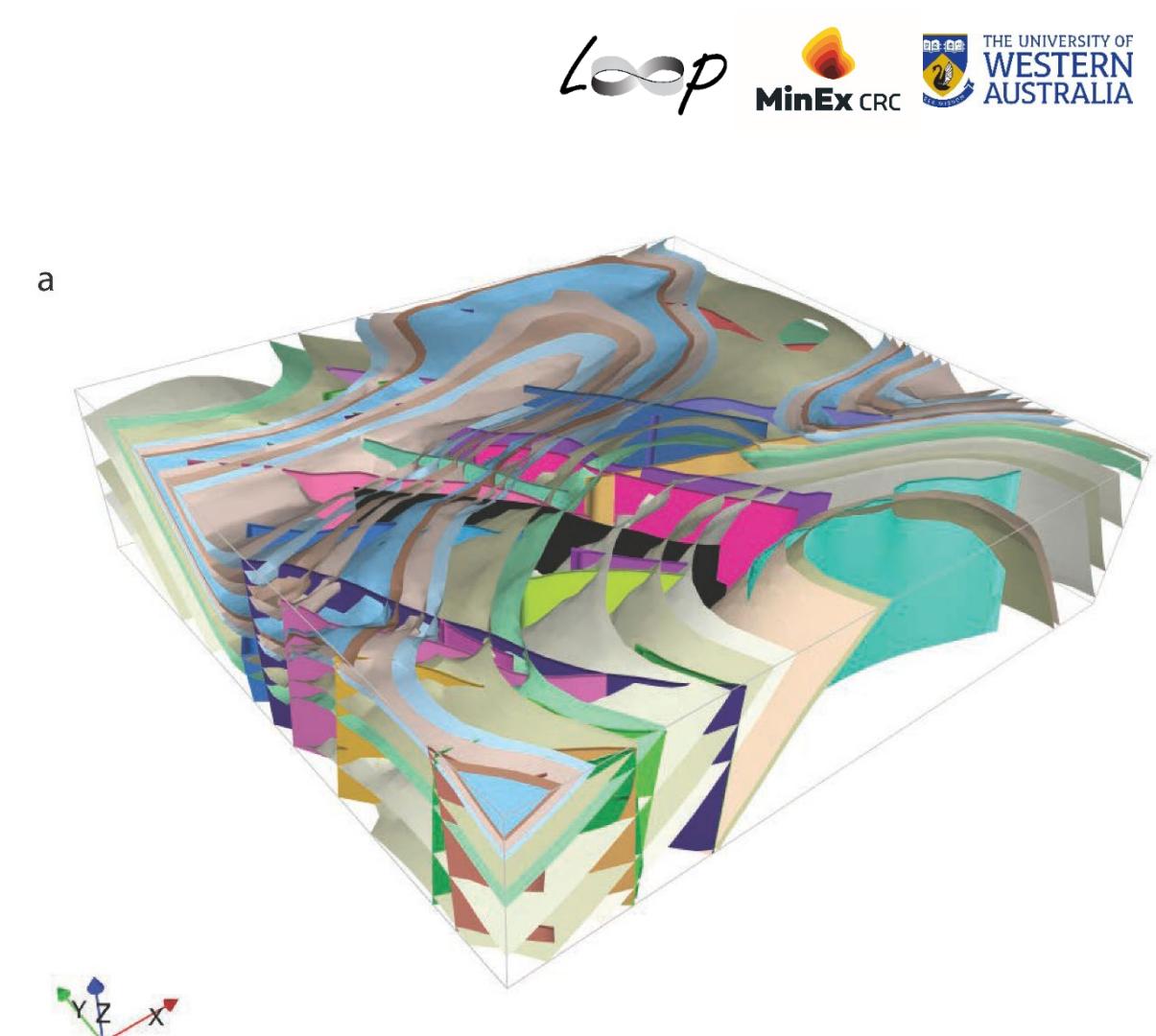
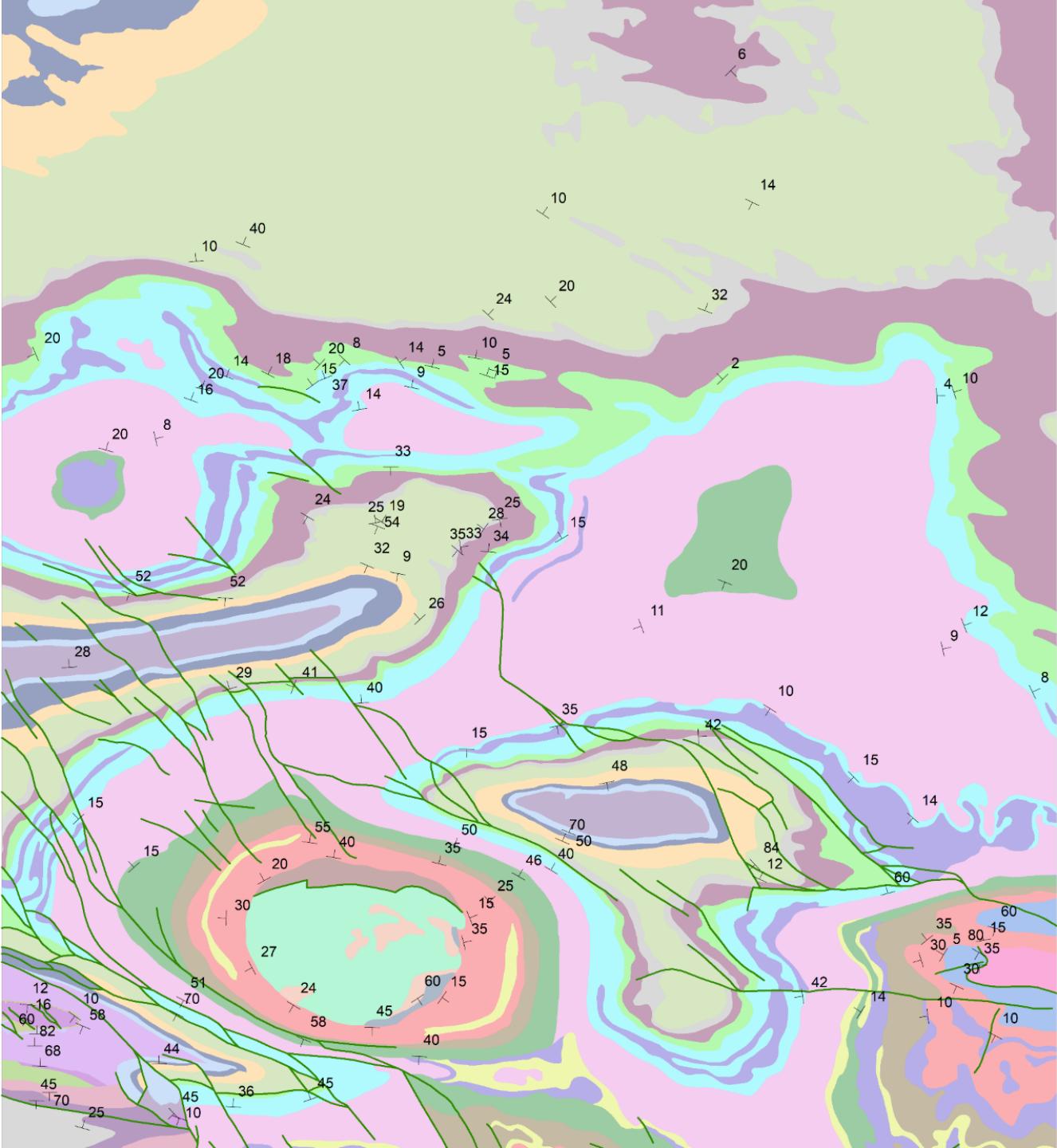


(g) fault strat offset



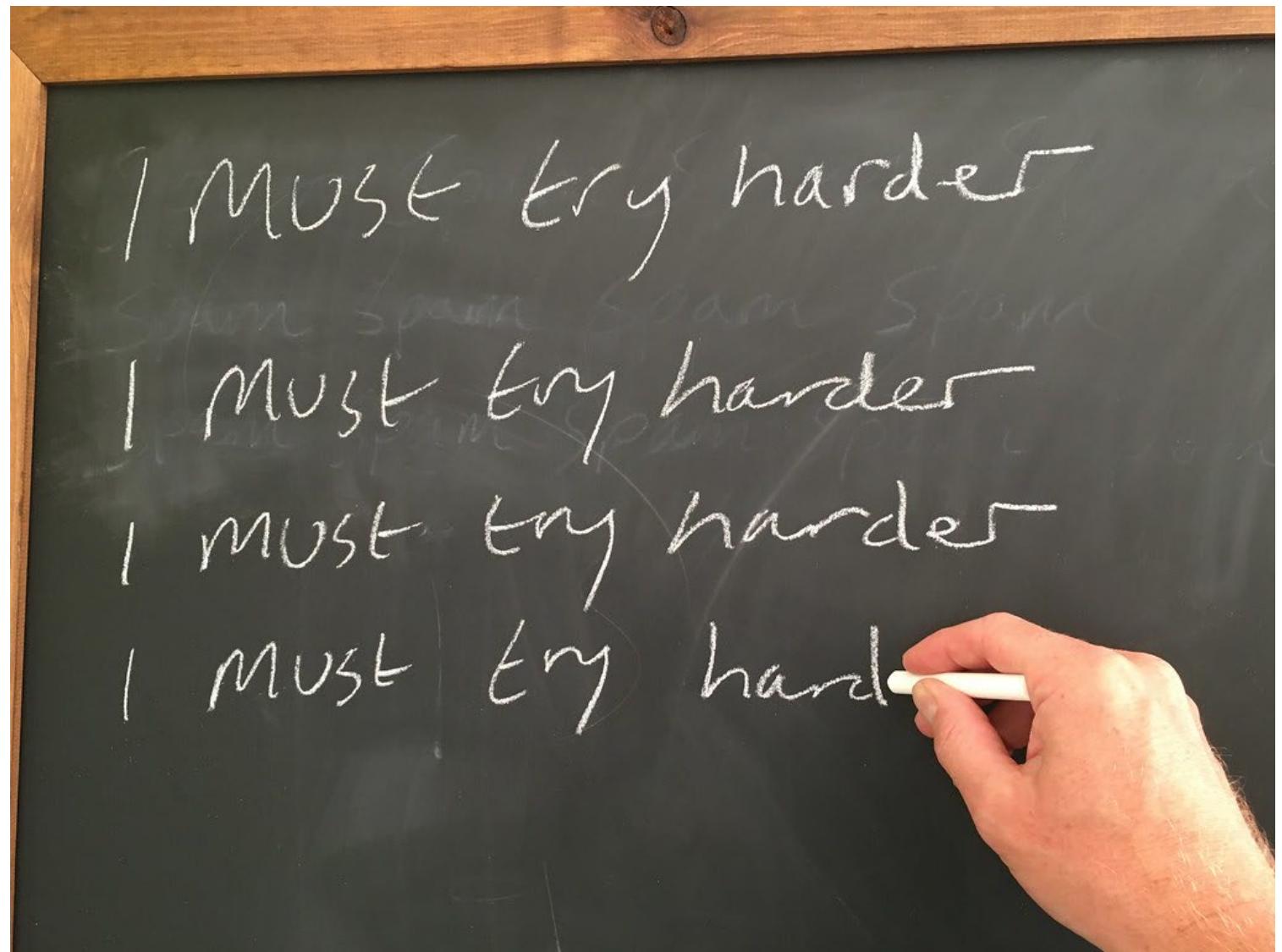
(h) downthrow



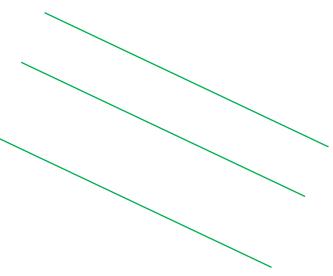
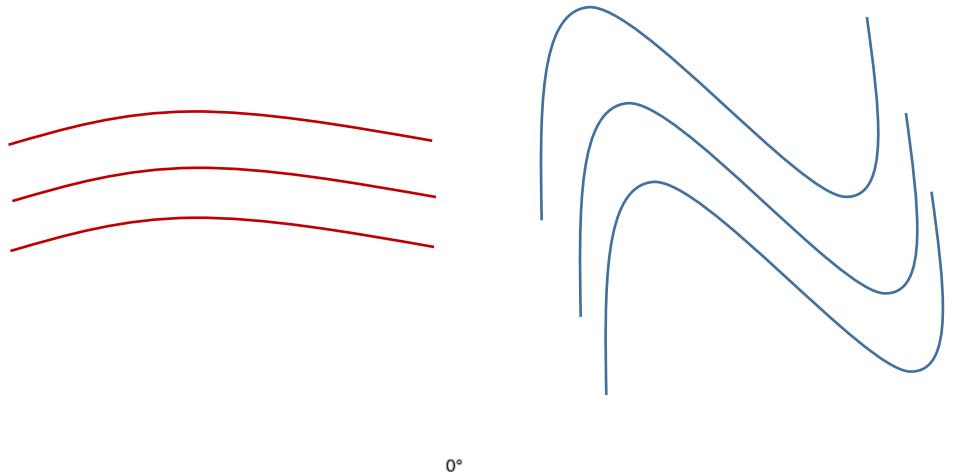


Weaknesses of maploop

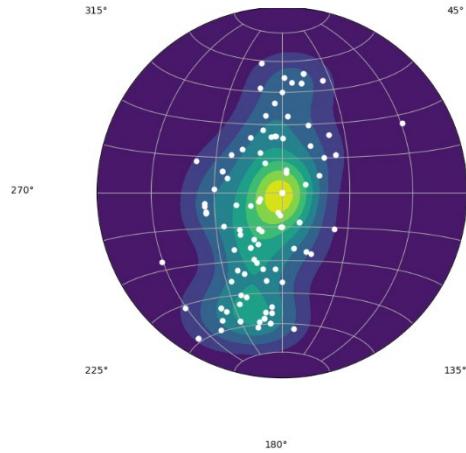
4
10



Structural domaining, at present



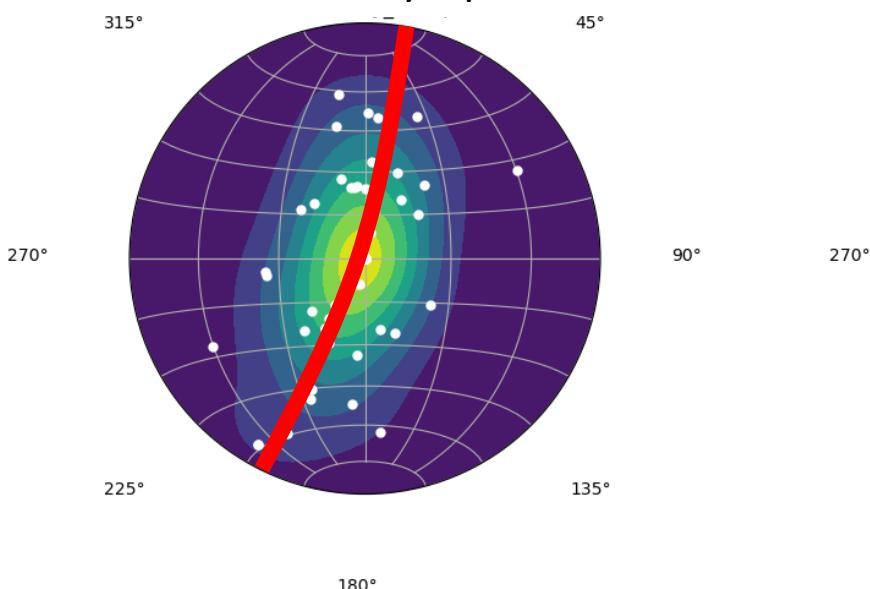
All bedding



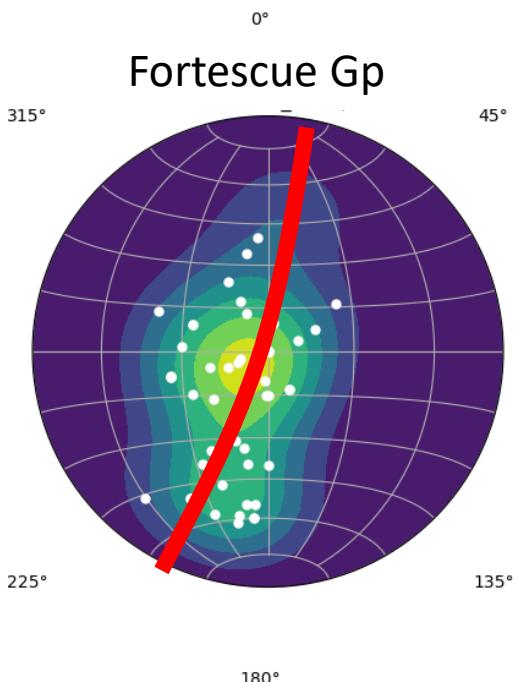
P
MinEx CRC



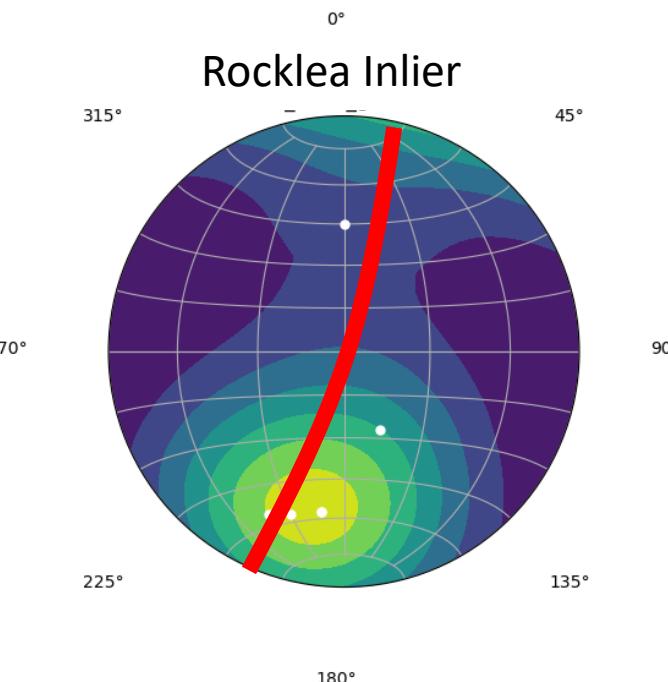
Hamersley Gp



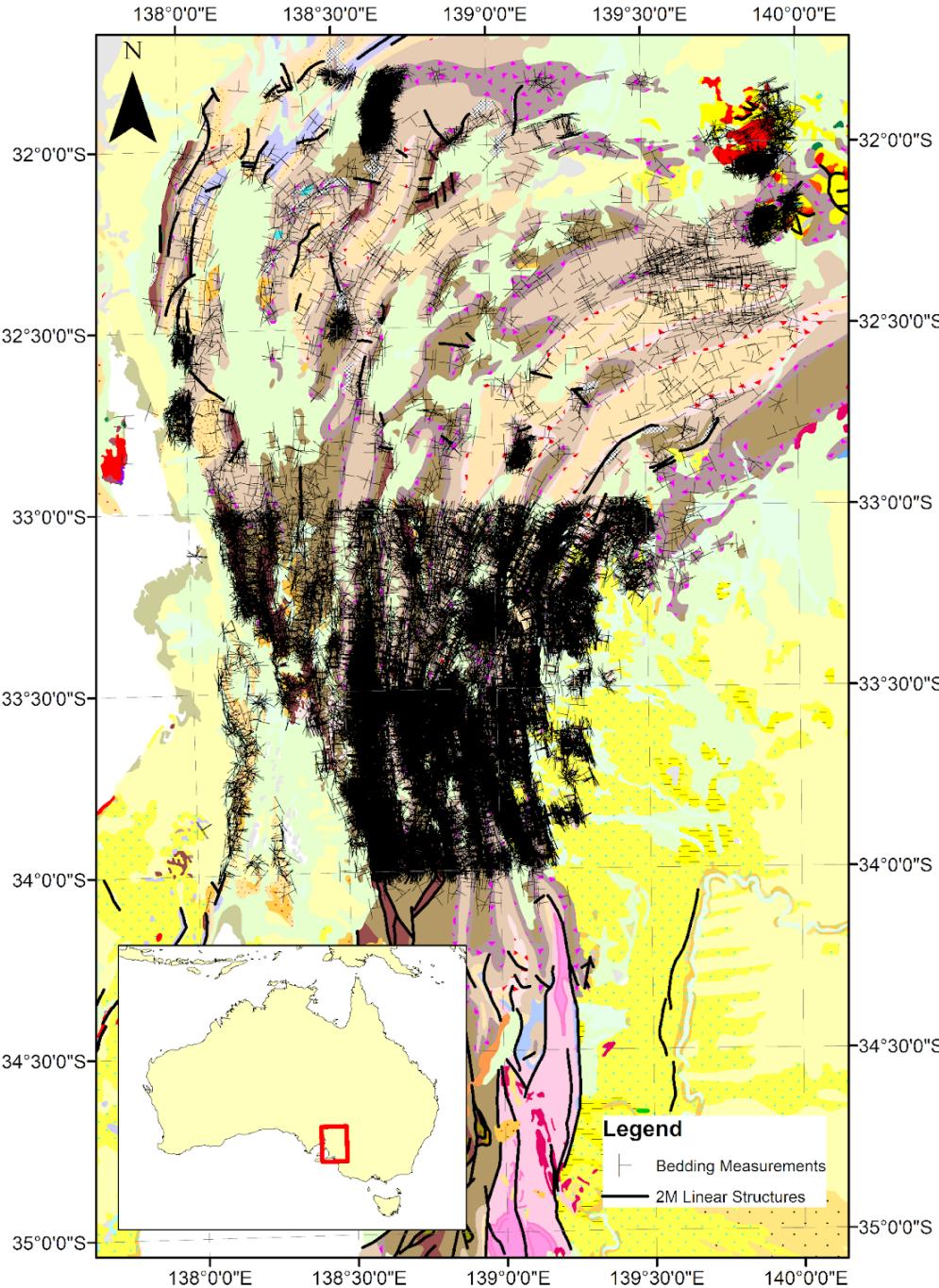
Fortescue Gp



Rocklea Inlier



Ranee Joshi

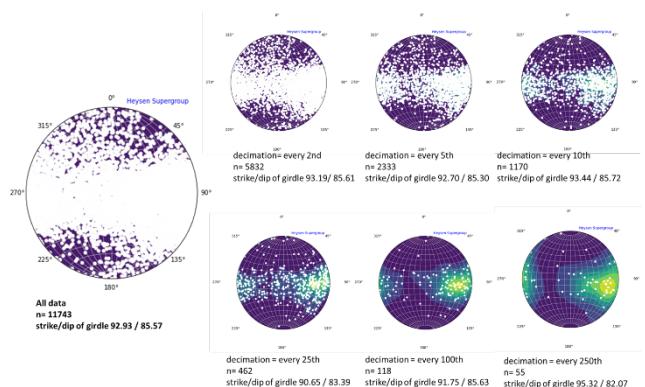
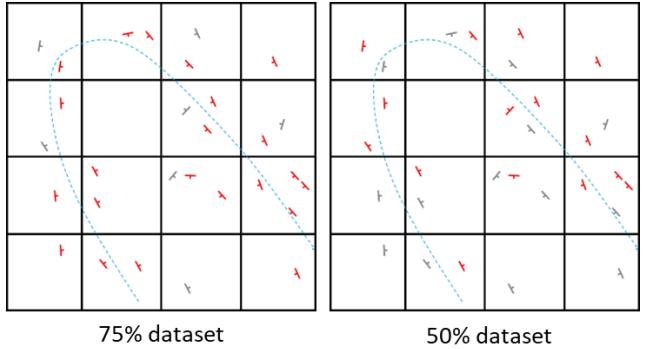
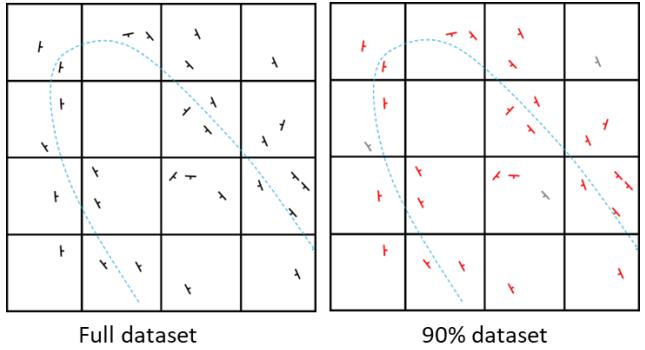


- Too much data in some areas:
 - Slow to calculate
 - Second-order fold structures
- Very variable data density

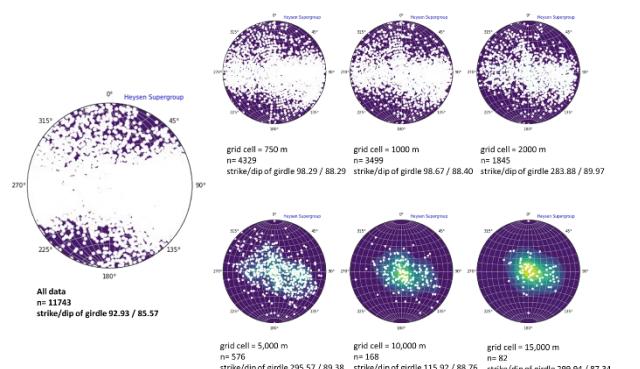
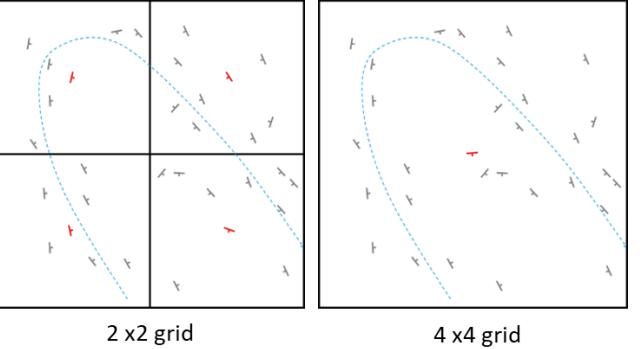
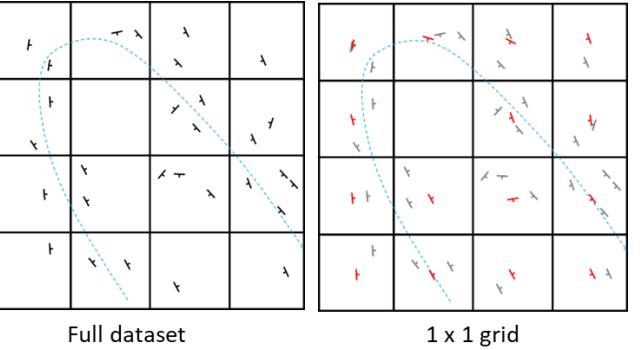
Upscaling of structural data:

Ranee Joshi

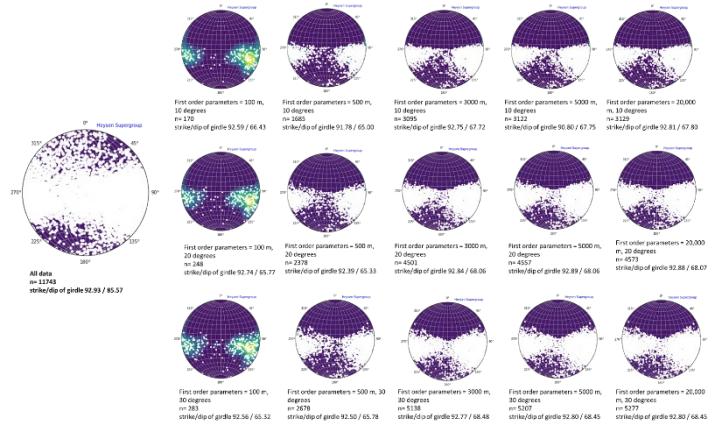
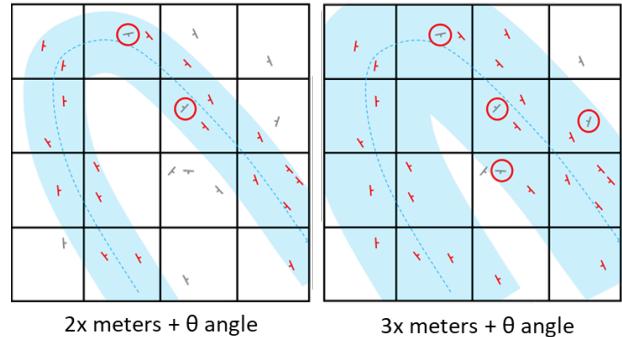
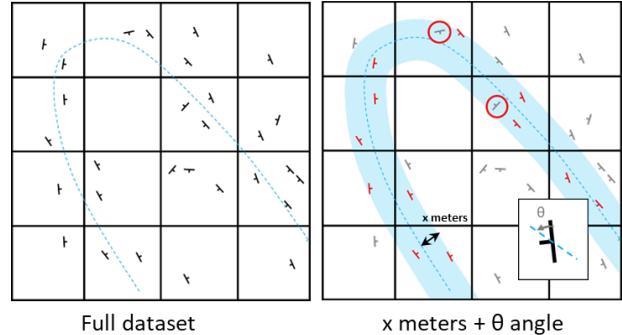
Keep X% of observations



Grid Approaches



Contact Aware Approaches

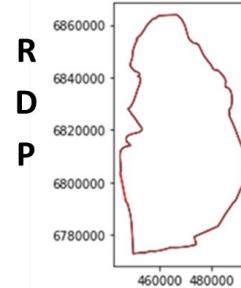


2. Ranee Joshi: Up/down scaling and variable scale models

Method	Description
Decimation on basal contacts (existing map2loop function)	This algorithm simply removes every nth point from the input polylines.
Ramer–Douglas–Peucker algorithm	The Douglas–Peucker algorithm selects the vertices to delete based on minimizing local area changes from node deletion.
Visvalingam–Whyatt algorithm	This method preserves topological relationships to adjacent polygons, preserves proximity to other polygons and preserves shape patterns that are necessary in geological interpretations.
Modified Visvalignam-Wyatt	This newly-developed code lists the shared borders and critical shared points to be preserved prior to applying the Visvalignman-Whyatt simplification, to ensure that triple points and shared polygon contacts are preserved.

Point Reduction: 80%

Area loss (km²): 0.13%



95%

1.29%

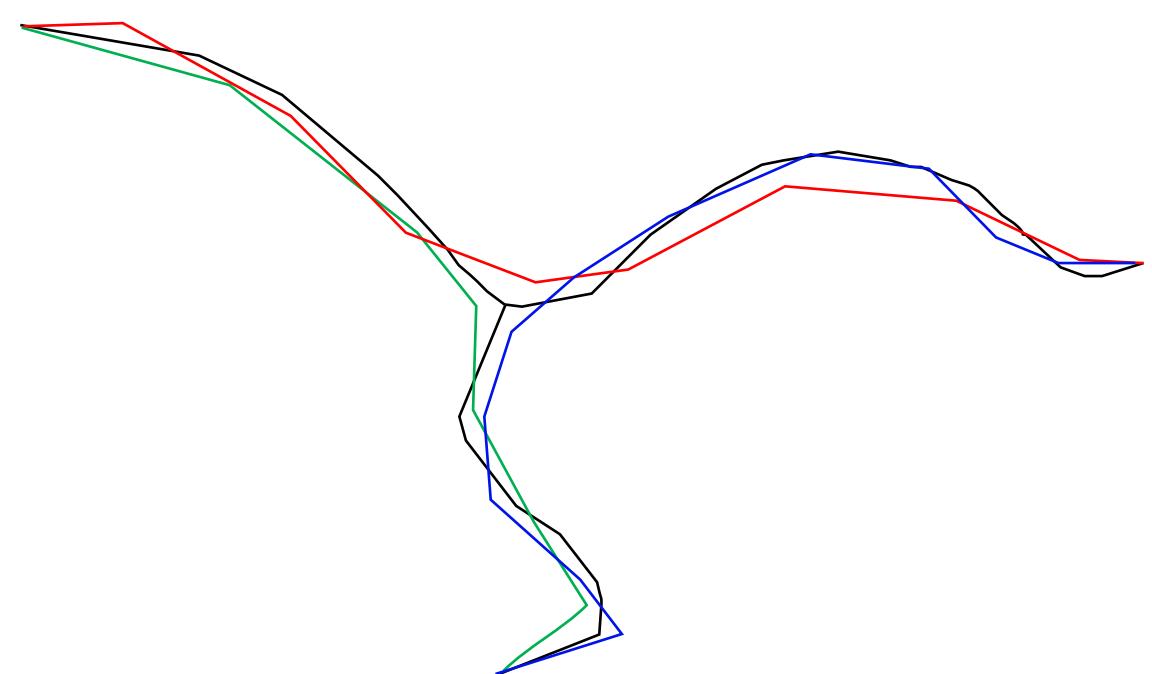
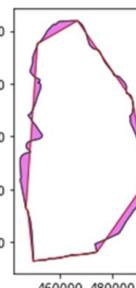
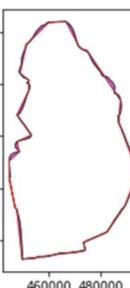
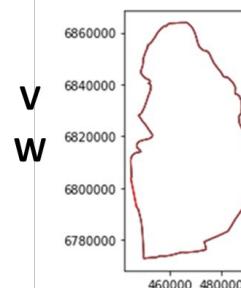


98.5 %

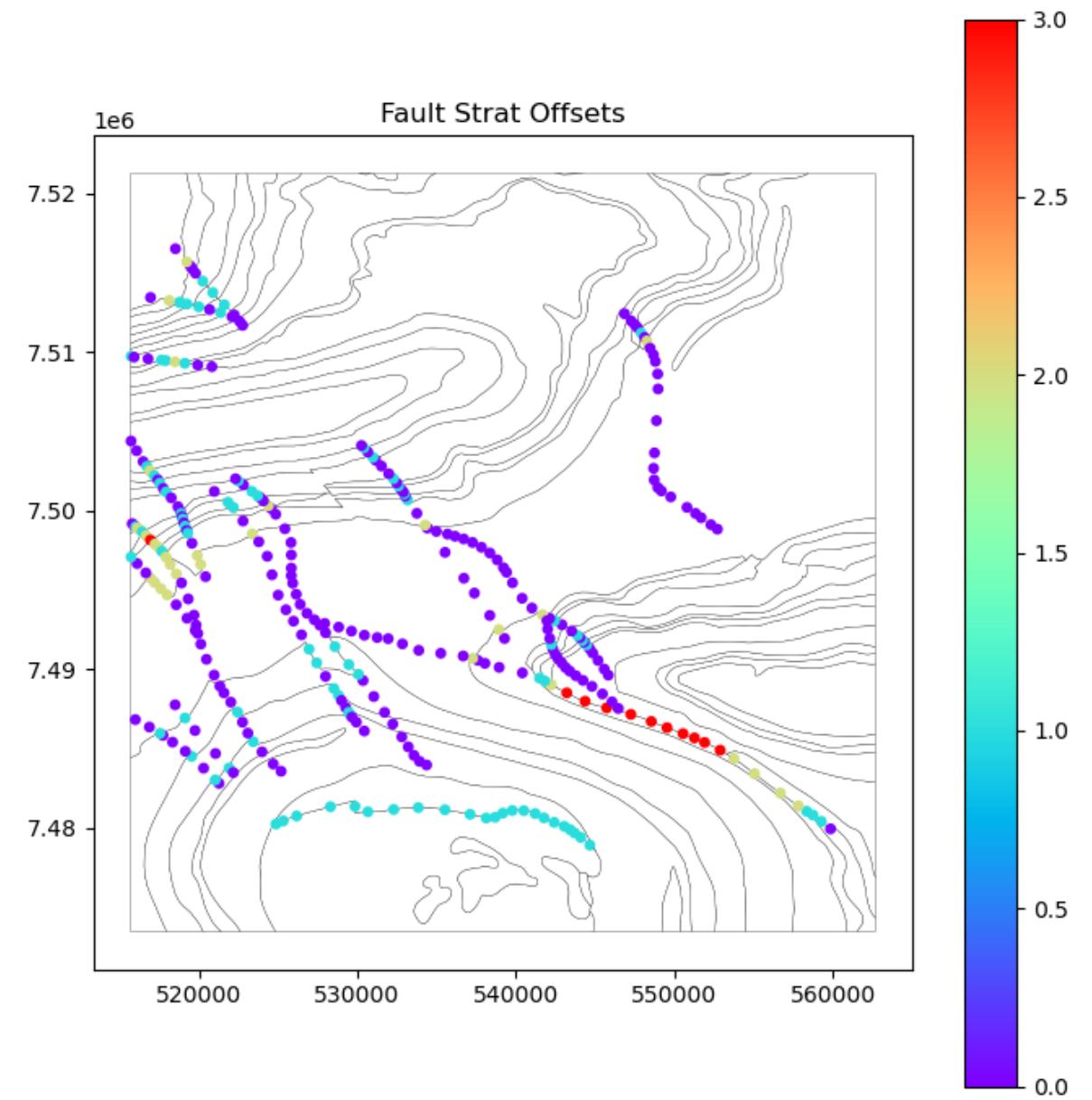
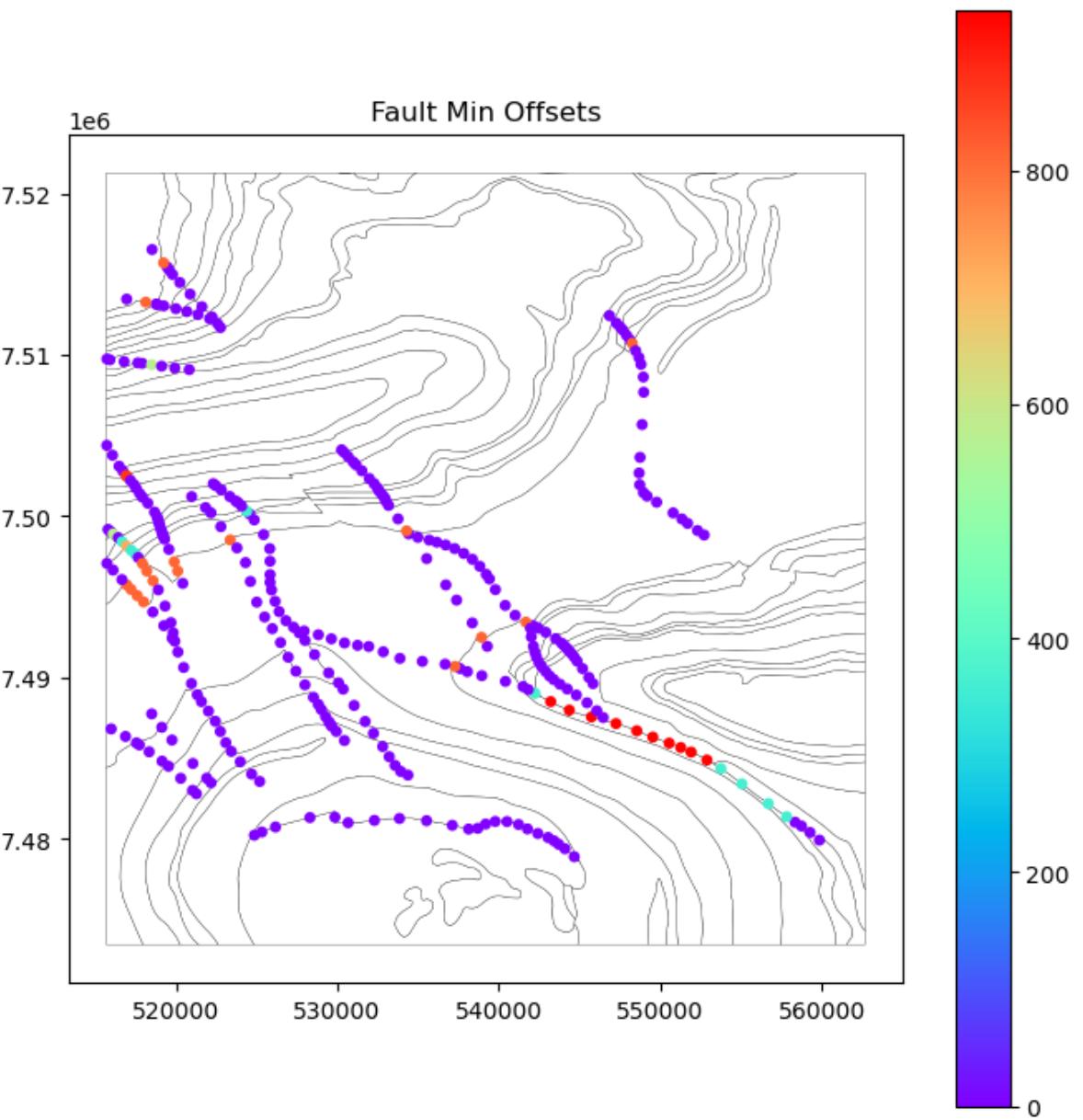
5.65 %



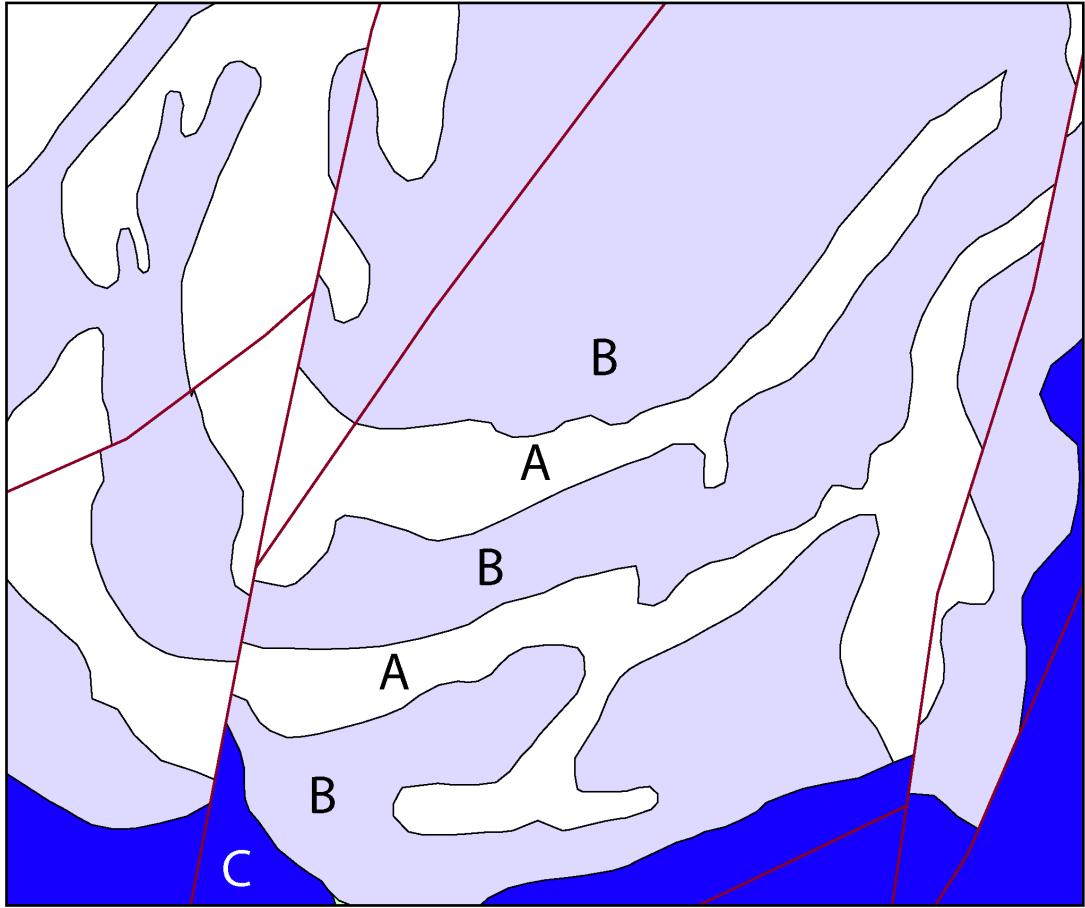
VW



Fault Offsets at present



More map analysis to overcome, or at least highlight map 'quirks':

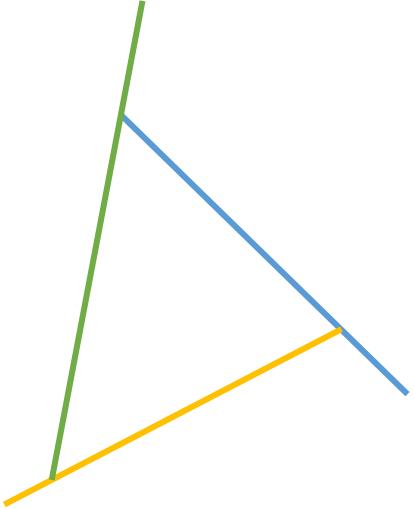


Does the C-B-A-B-A-B sequence simply reflect lithology, or is it folded and or faulted stratigraphy?

Fault topology



No offsets, possible but unlikely



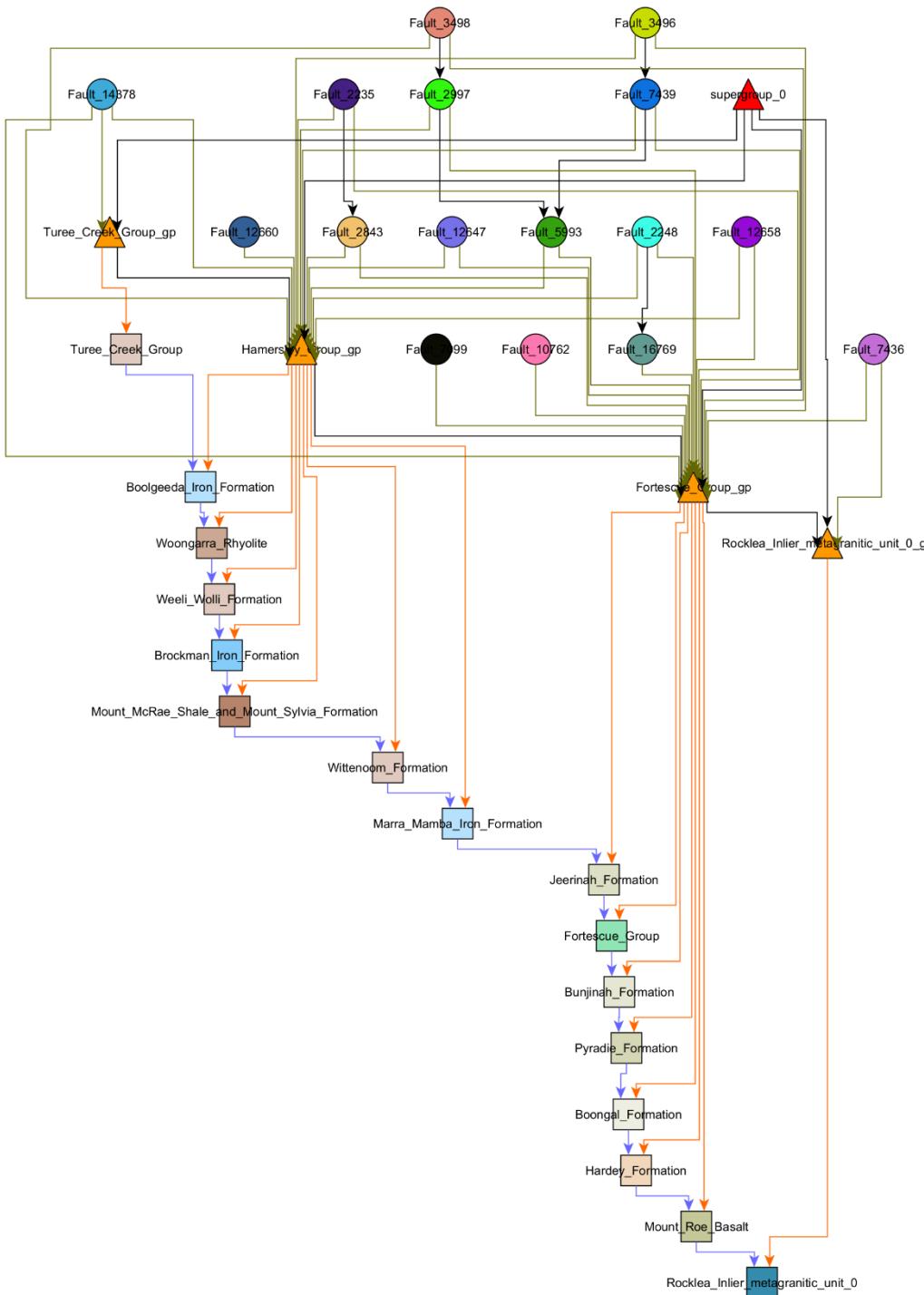
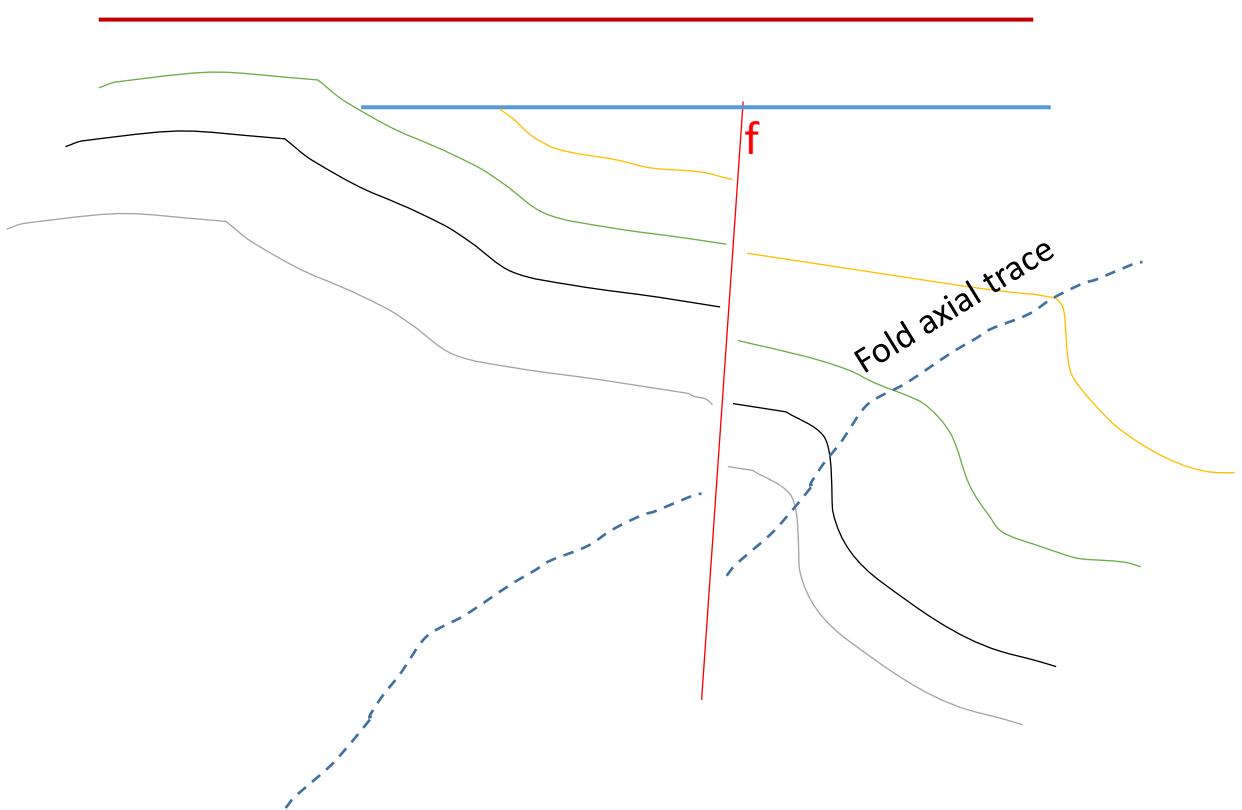
Incoherent ages

Recoding formations, e.g. when a polygon is labelled as a Group

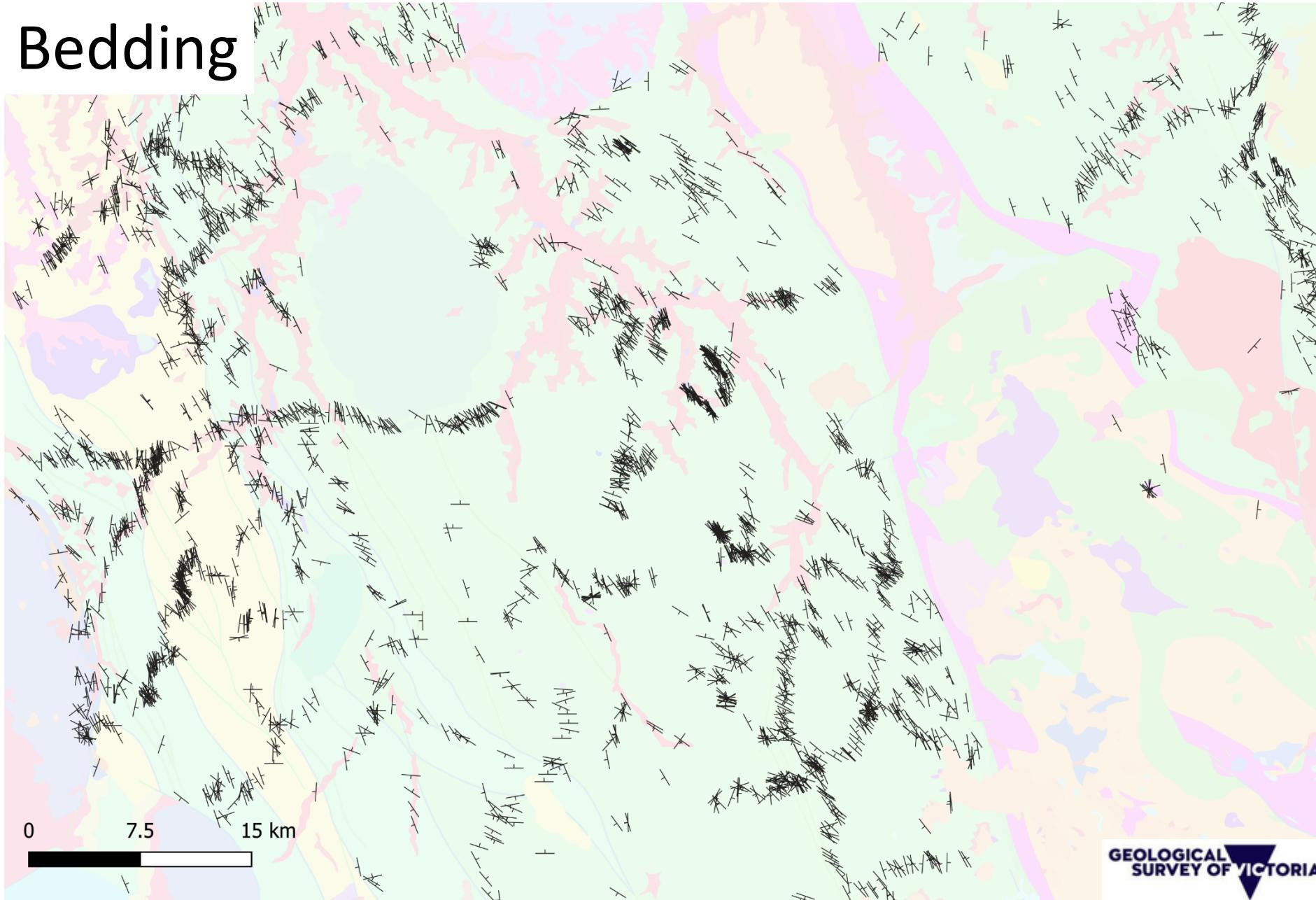
Stratigraphy and Fault Age relationships, at present:

One of many possible age sortings is chosen for both faults and stratigraphy

No use of Faults vs Folds vs Stratigraphy to further refine age relationships

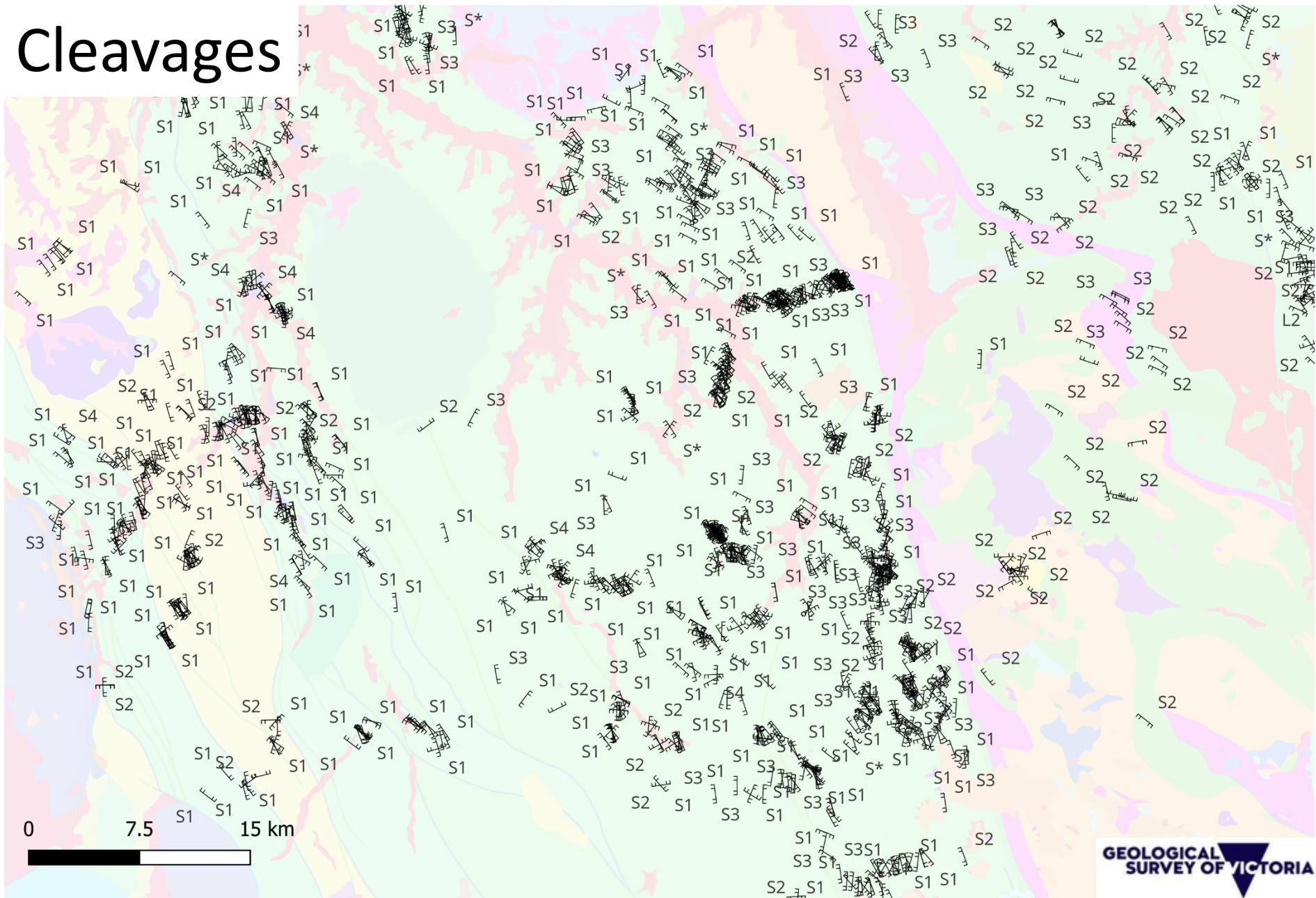


Bedding

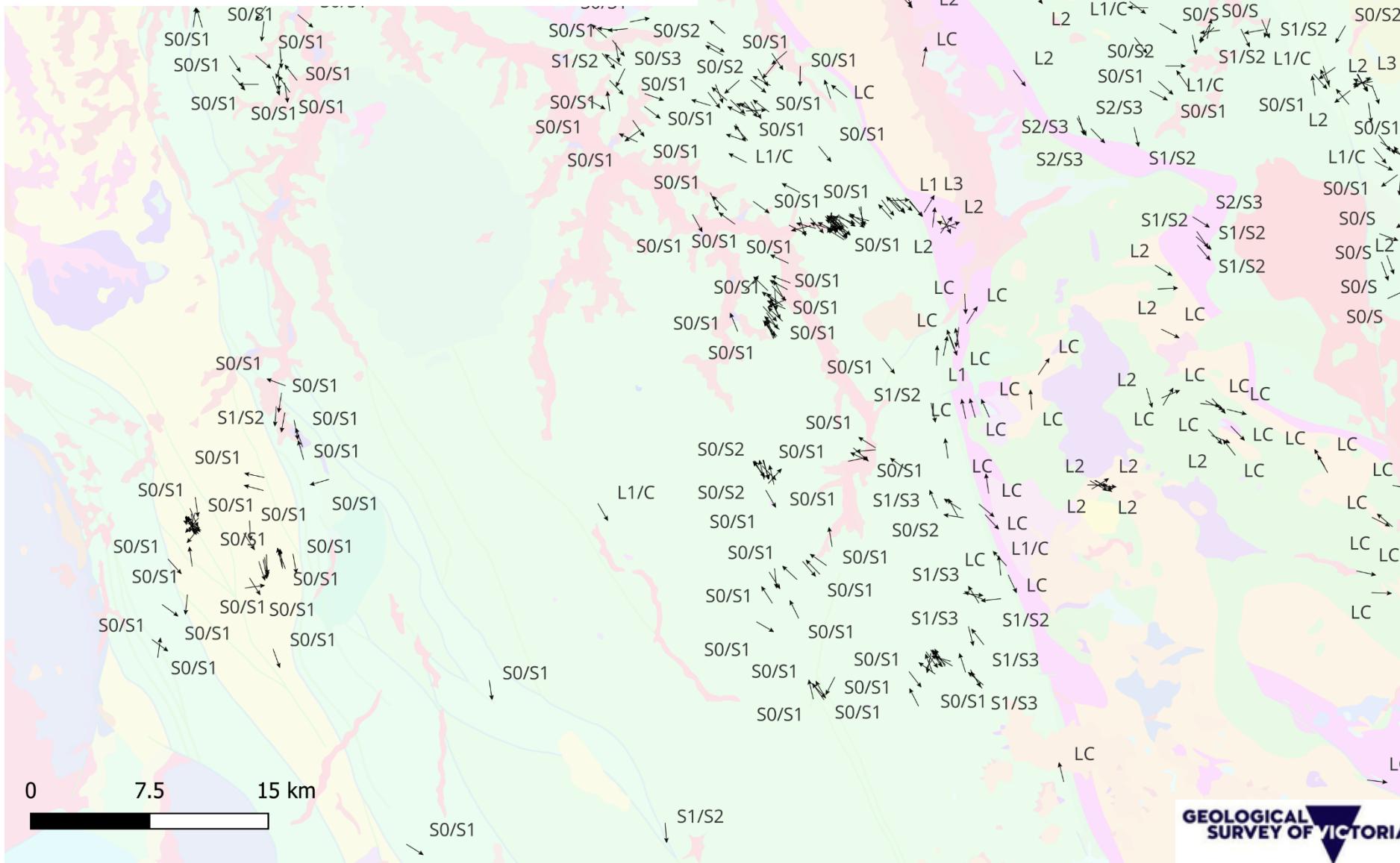


What we currently use
in map2loop

Cleavages



Intersection Lineations



Local vergence calculations will feed into LoopStructural's age-aware calculations

map2loop automation :

- Significantly reduces the time to first prototype models;
- Allows reproducible modelling from raw data, whereas current Uncertainty Quantification workflows start from model-ready inputs;
- Clearly separates the primary observations, interpretations, derived data and conceptual priors during the data reduction steps; and
- Provides a homogenous pathway to Sensitivity Analysis, Uncertainty Quantification, Multiscale Modelling and Value of Information studies.



Proof of concept, use at your own risk!

Loop

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