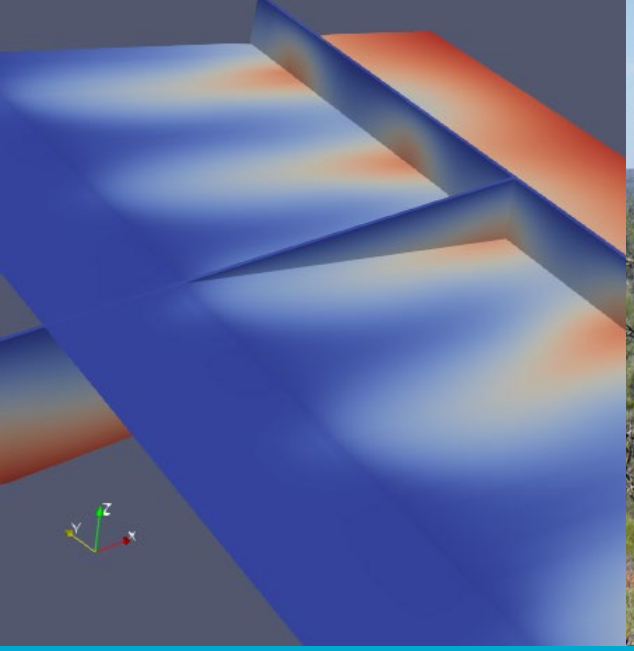

An integrated study of the McArthur River mineral system: From geochemistry, geophysics and sequence stratigraphy to basin-scale models of fluid flow

Heather Sheldon, Peter Schaubs, Teagan Blaikie, Marcus Kunzmann, Susanne Schmid and Sam Spinks

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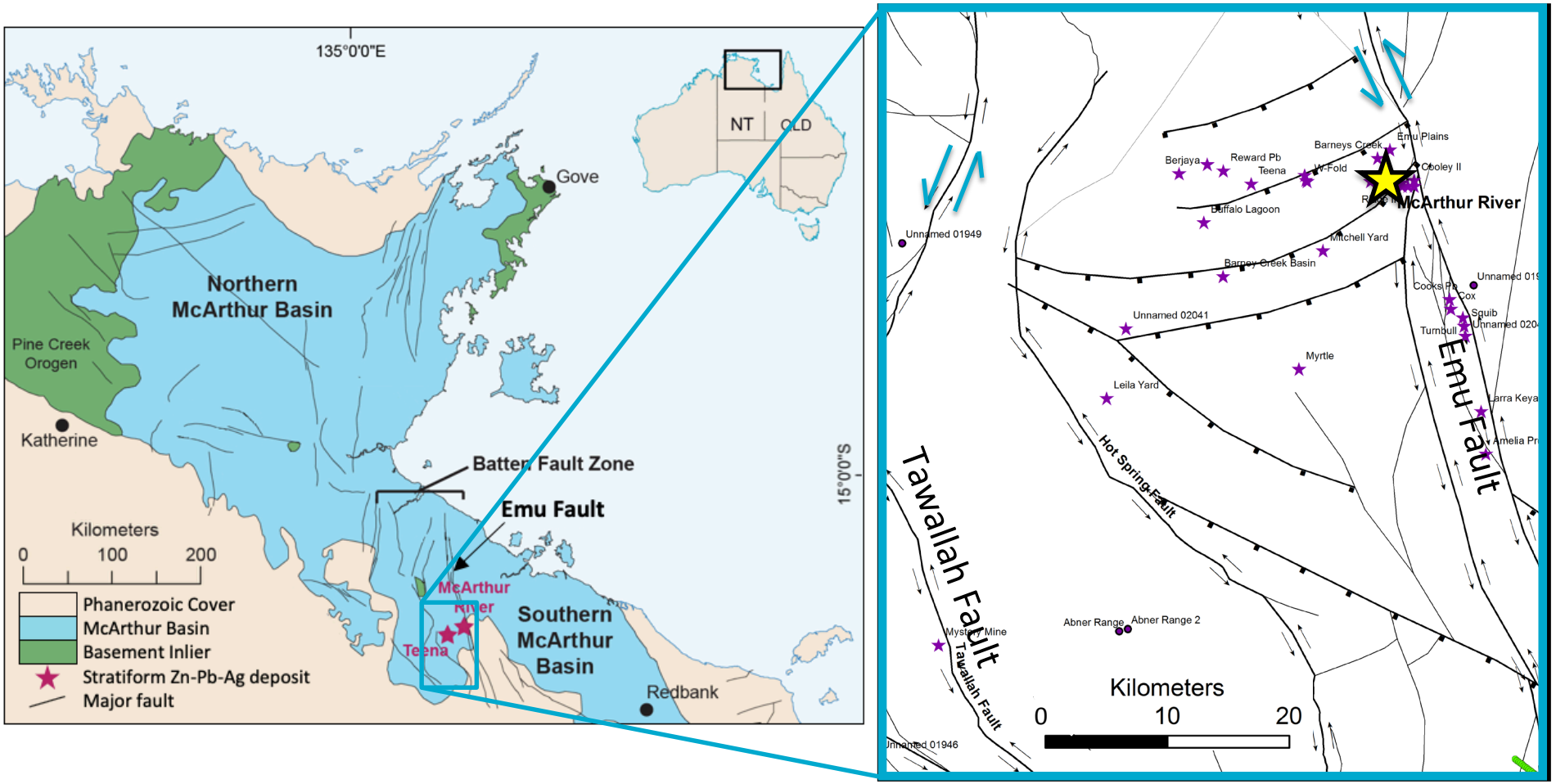
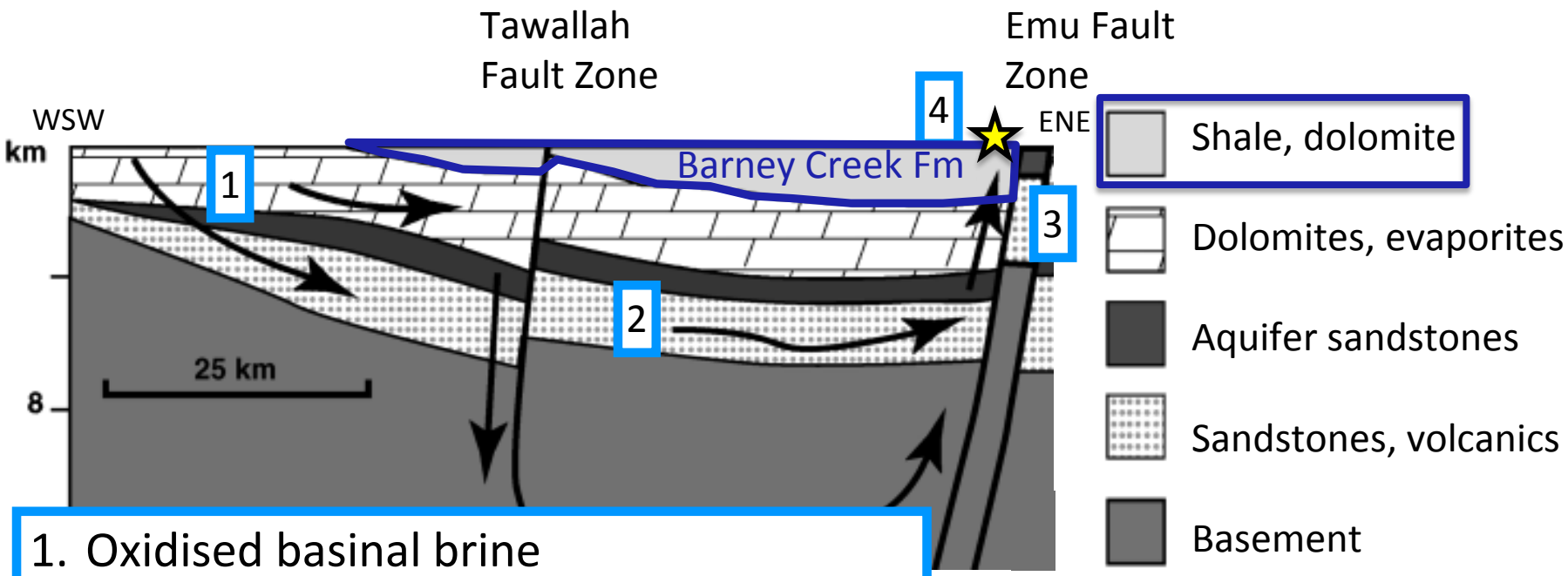
Outline

- Conceptual model of the McArthur River mineral system
- Numerical models: Geometry and properties
- Scenario testing:
  - Diagenetic vs. syngenetic mineralisation
  - Effects of deformation: Extension vs. shortening

McArthur River: Geological setting



McArthur River: Conceptual model



1. Oxidised basinal brine
2. Metals leached from volcanic units
3. Hot brine ascends Emu fault
4. Deposition in anoxic sediments, at or below seafloor

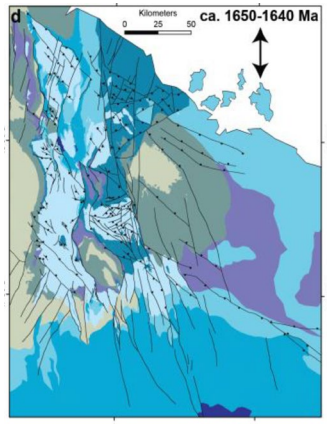
Fluid flow drivers:

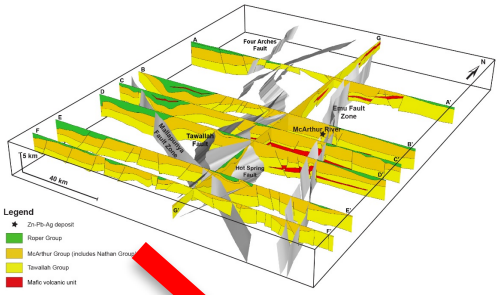
- Density (temperature, salinity)
- Deformation?

After Garven et al. (2001), Large et al. (1998)

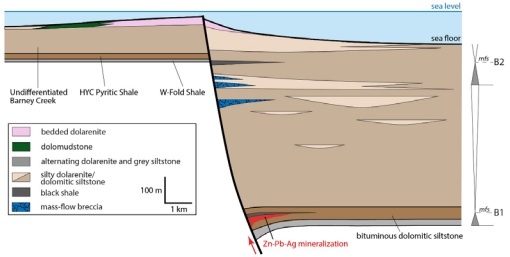
Integrated study

Tectonic regime

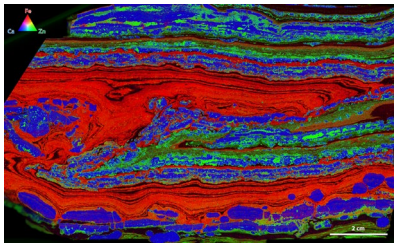


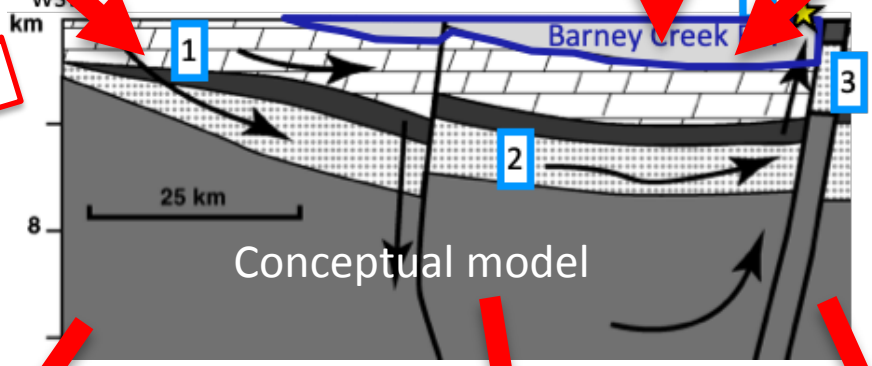


Stratigraphy

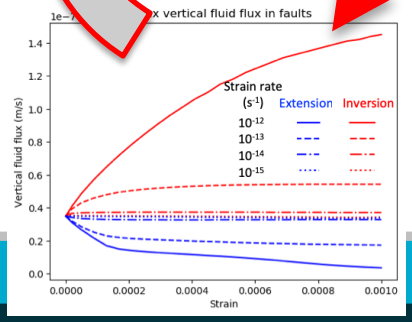


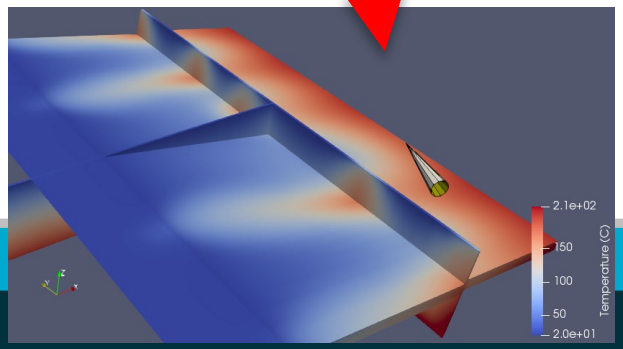
Geochemistry and petrography

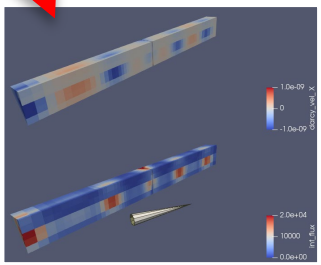




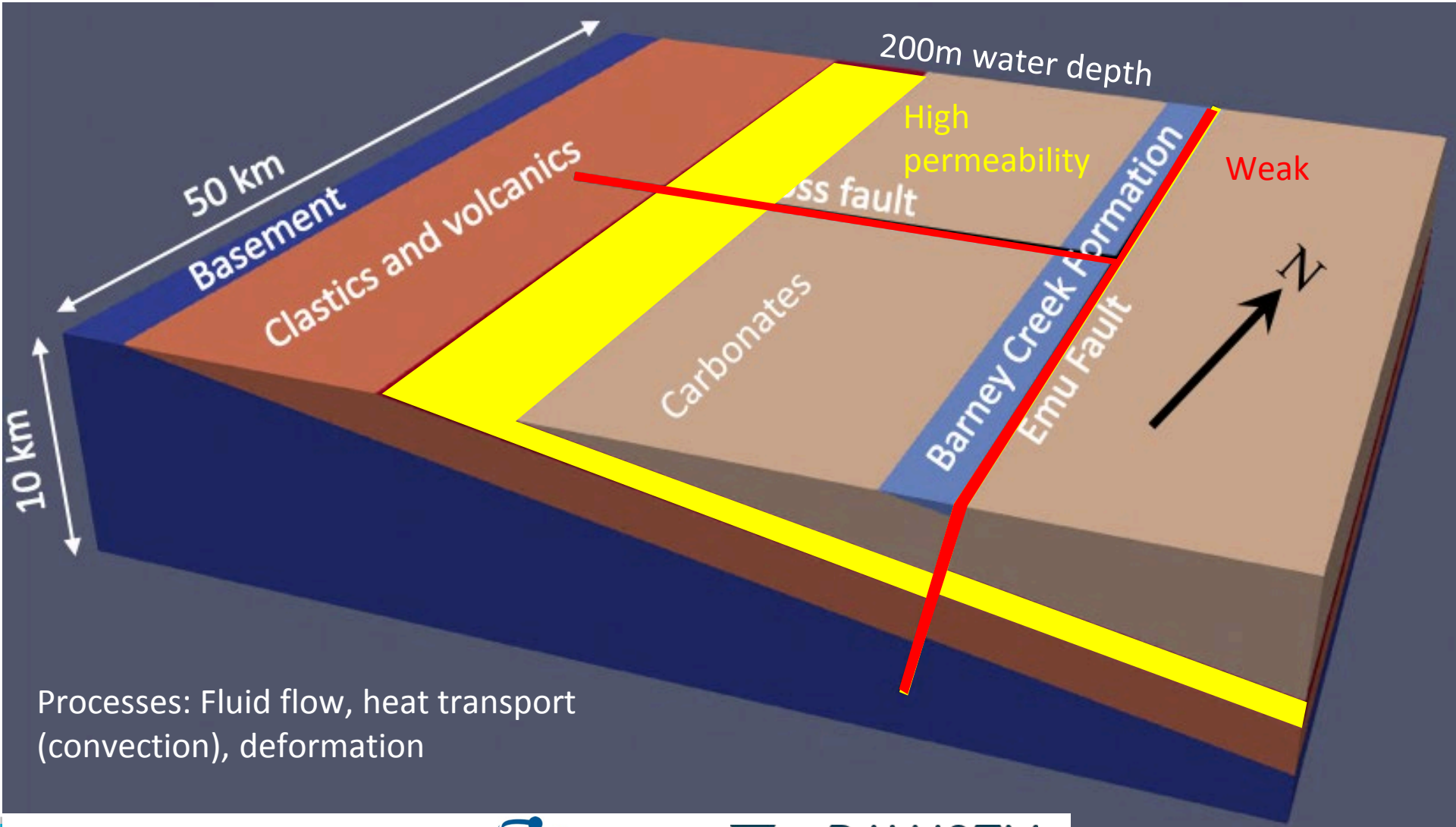
Numerical models







Numerical model



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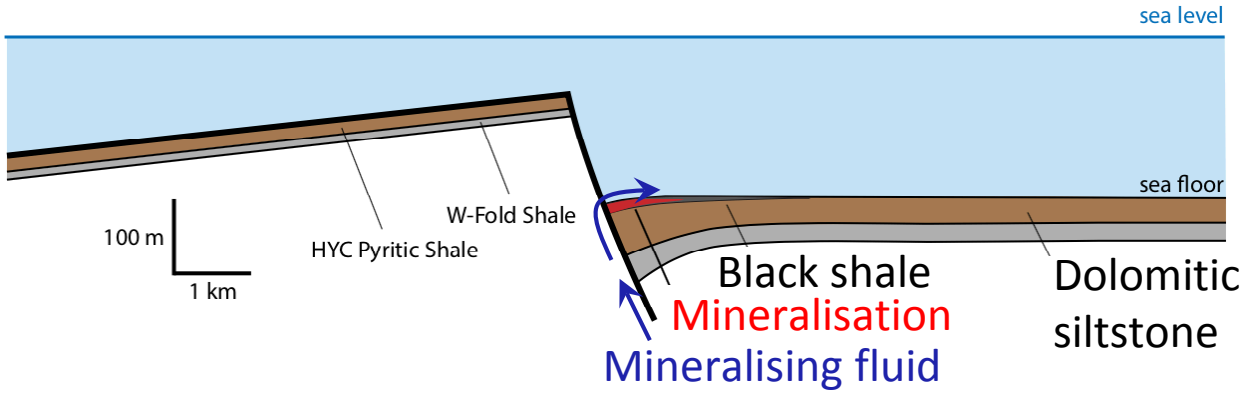
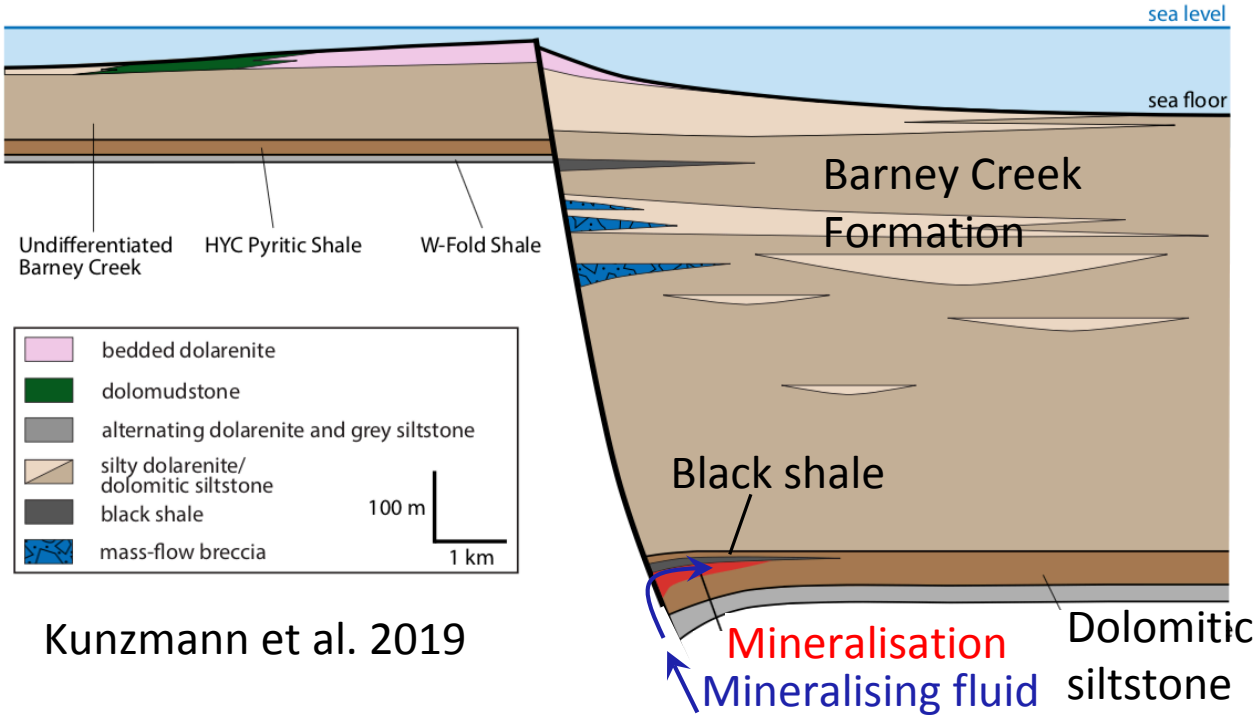
Scenario testing 1: Diagenetic vs. syngenetic mineralisation

Stratigraphic interpretation

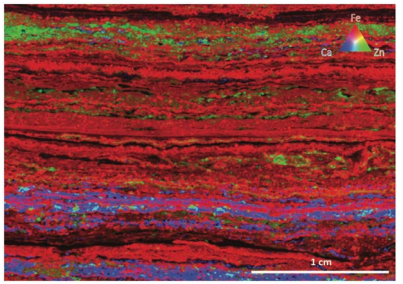


Syngenetic scenario: black shale = chemical trap on seafloor



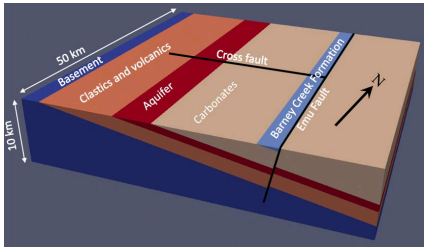
Kunzmann et al. 2019

Diagenetic scenario: black shale = seal, diverting fluids into BCF

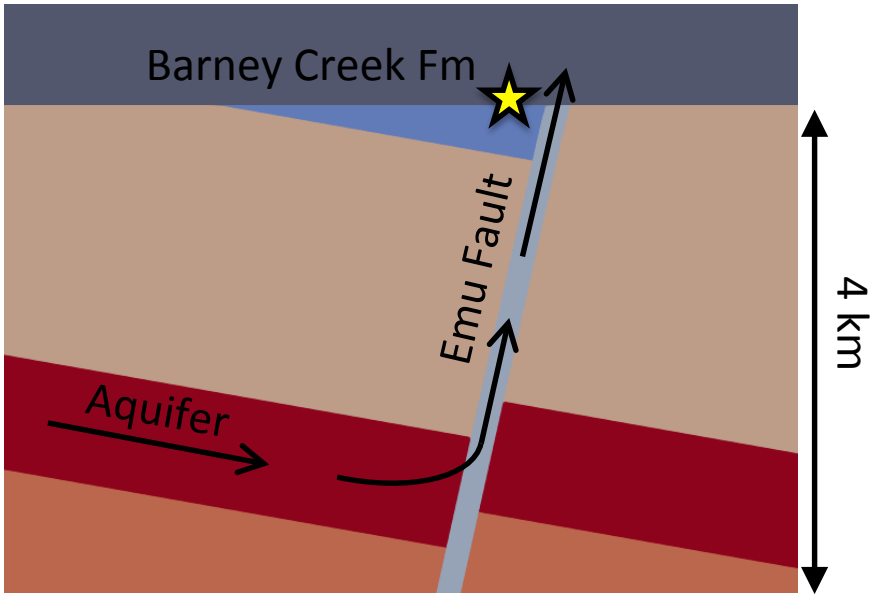


Spinks et al. 2019

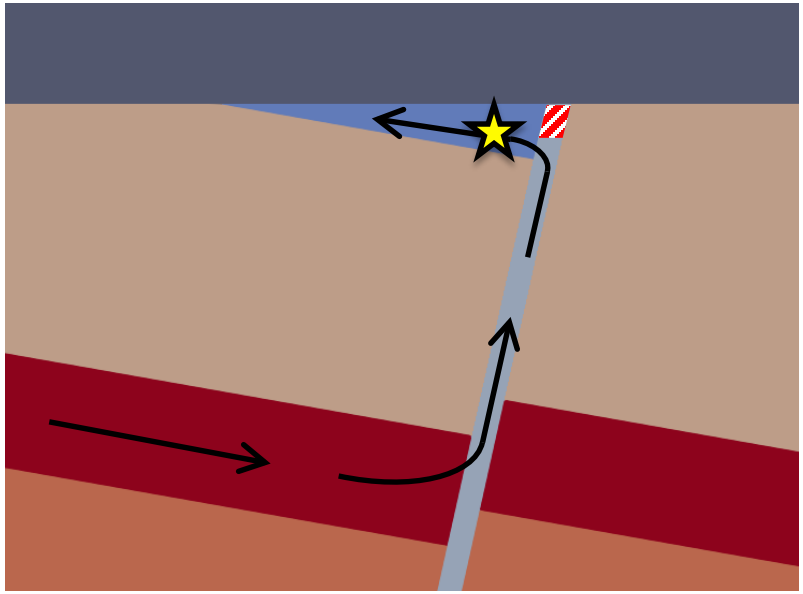
Scenario testing: Diagenetic vs. syngenetic mineralisation



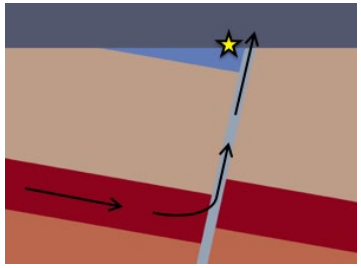
Syngenetic: Fluid flows up Emu Fault to seafloor



Diagenetic: Fluid diverts out of Emu Fault into BCF

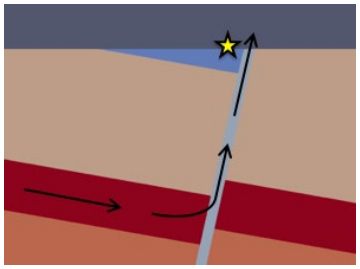


Results: Thermal convection, syngenetic scenario

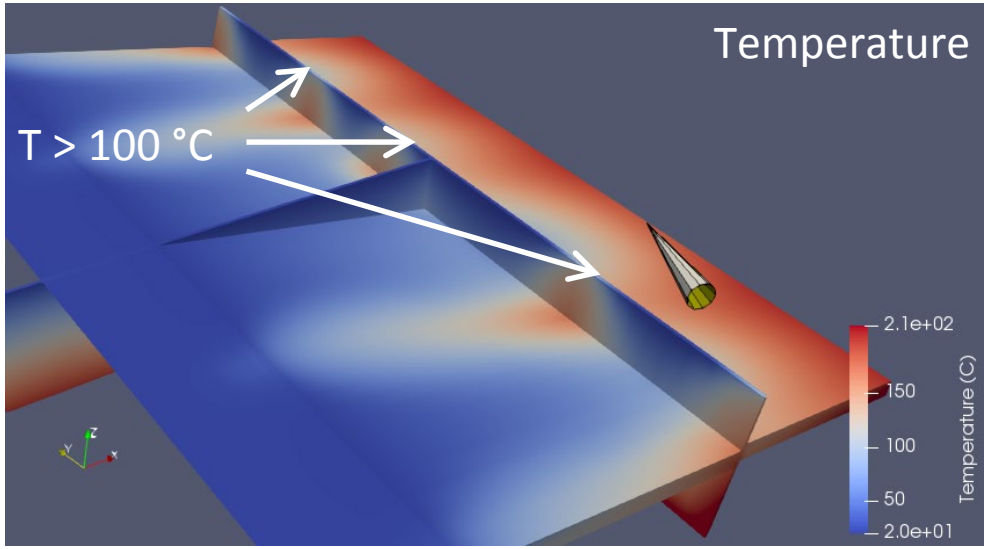


Temperature and fluid flow in aquifer and faults

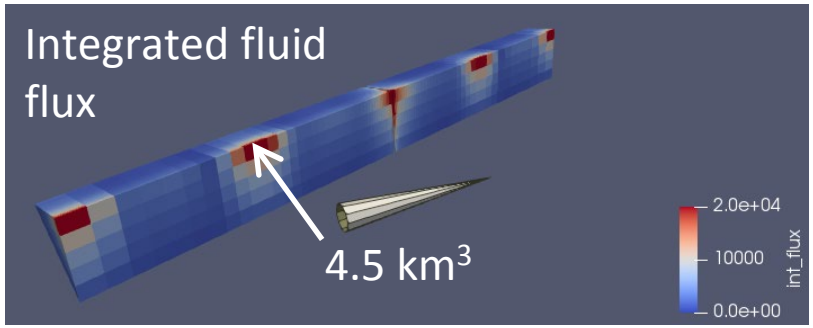
Results: Thermal convection, syngenetic scenario

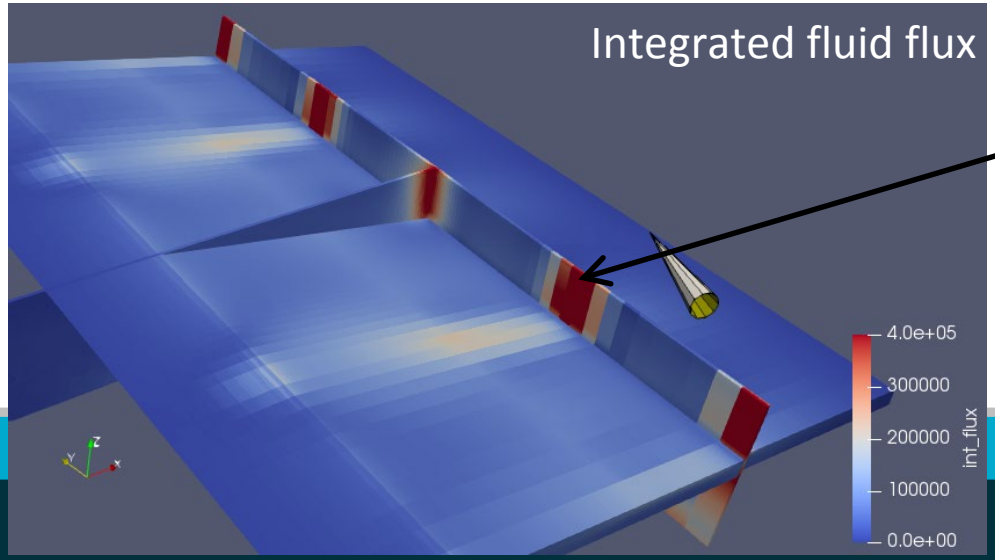


Aquifer and faults



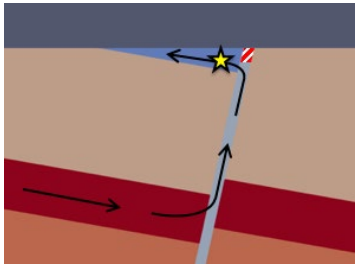
Barney Creek Fm
(vertical exaggeration x10)





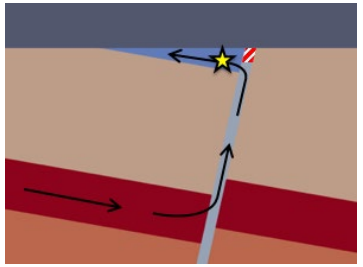
135 km^3 fluid in 1 m.y.
c.f. 20 km^3 required for McArthur River deposit (20 Mt Zn)

Results: Thermal convection, diagenetic scenario

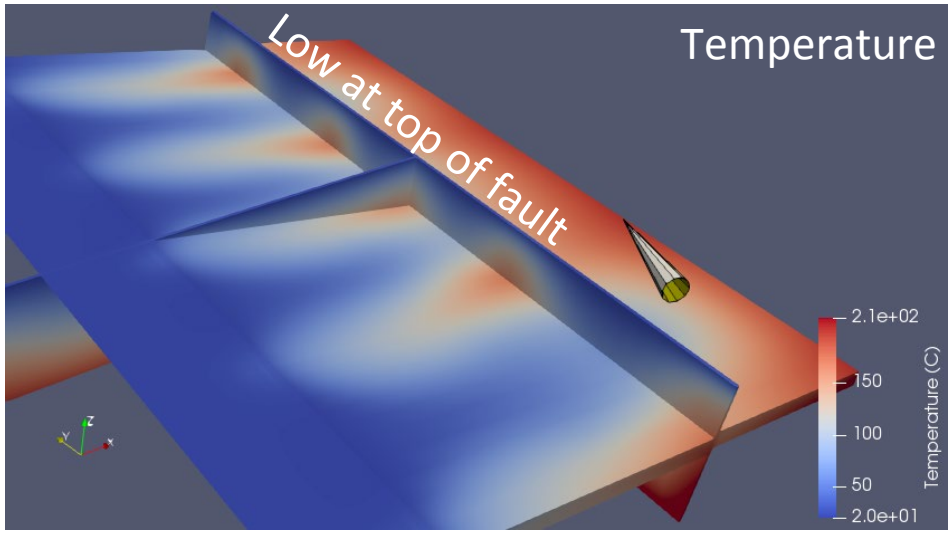


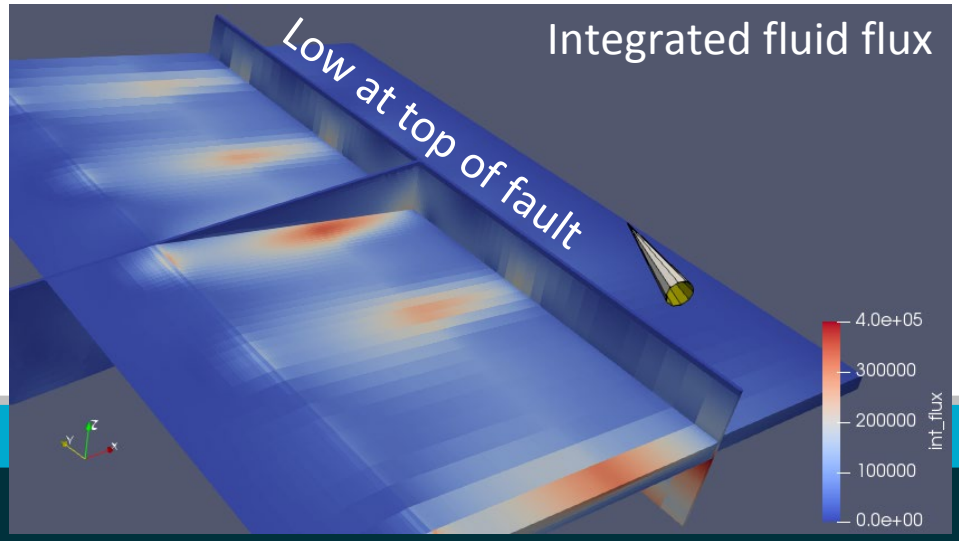
Temperature and fluid flow in aquifer and faults

Results: Thermal convection, diagenetic scenario

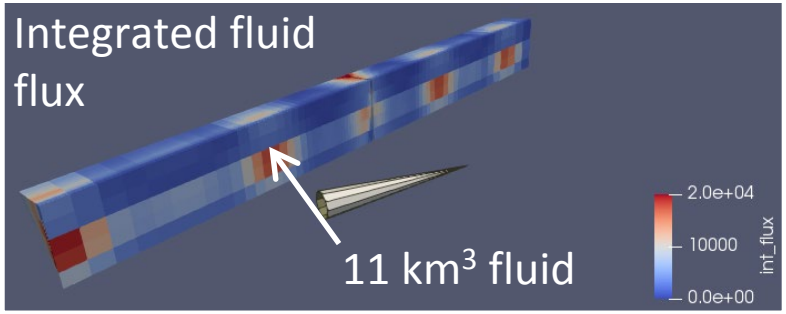


Aquifer and faults



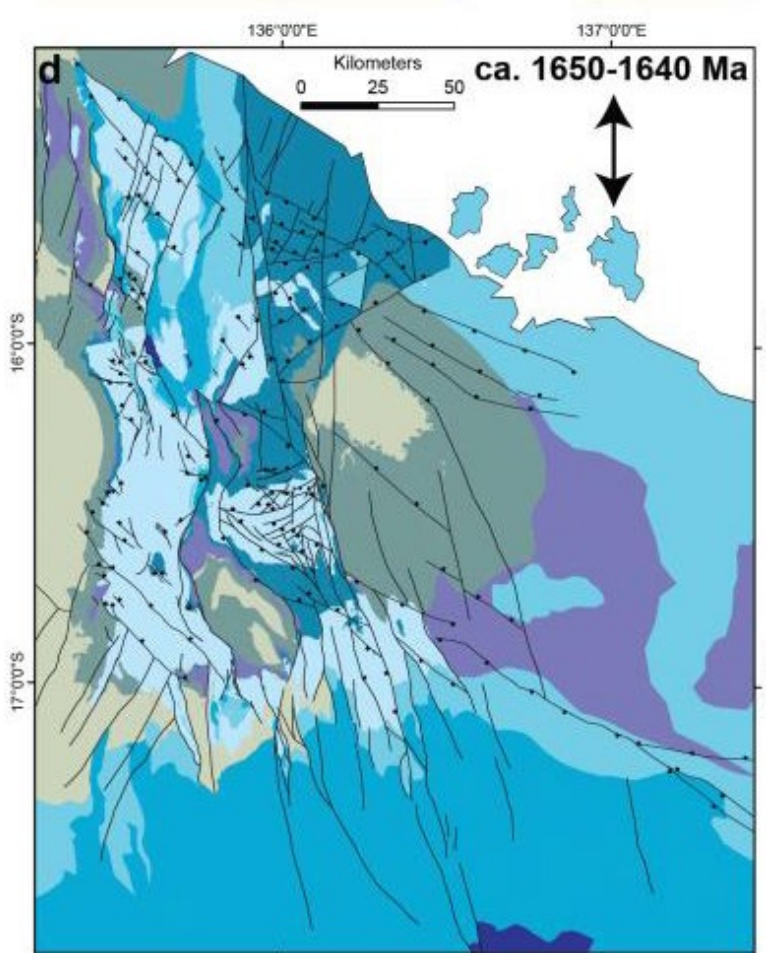


Barney Creek Fm
(vertical exaggeration x10)



Scenario testing 2: Effects of extension and shortening on thermal convection

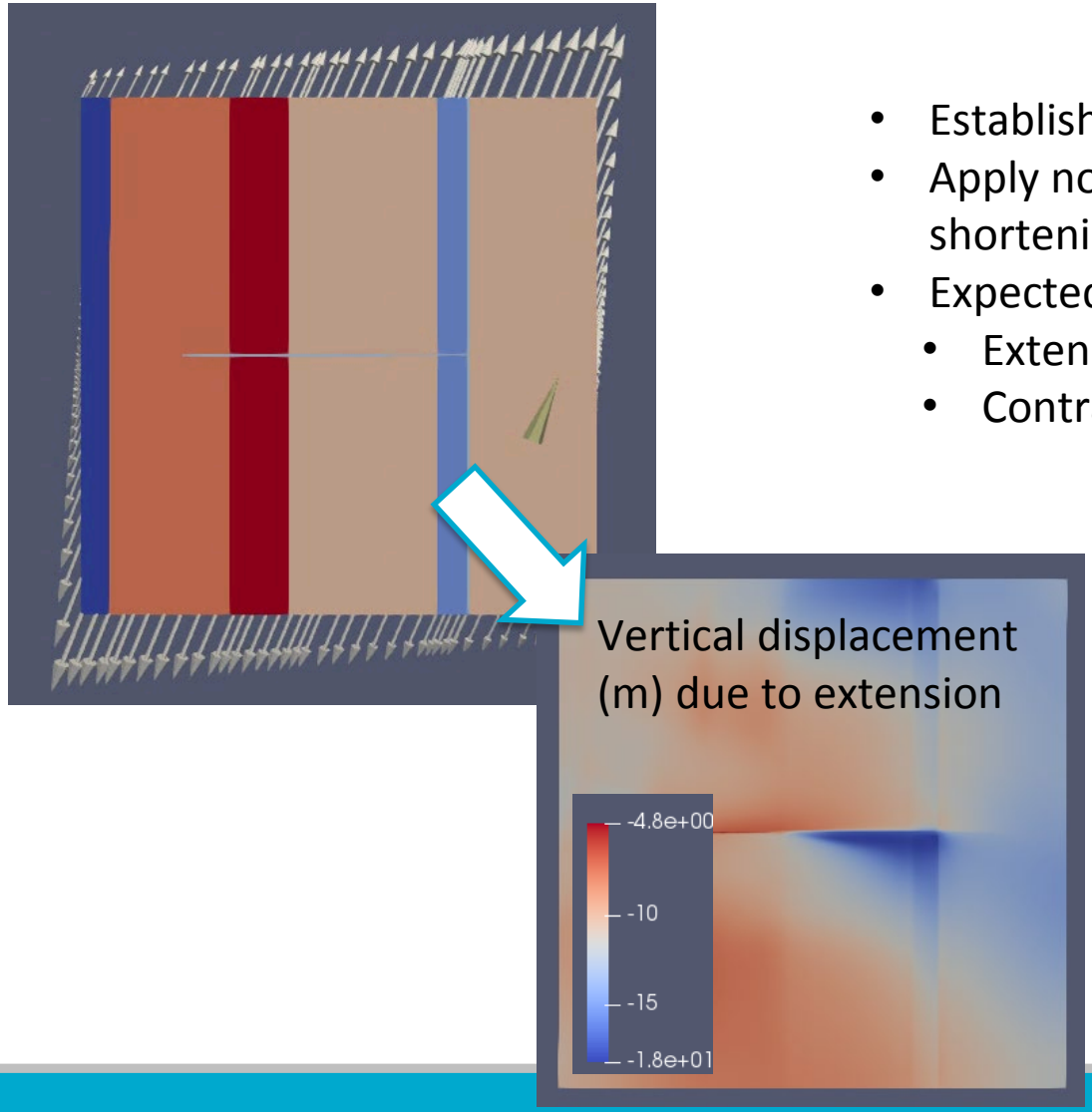
Tectonic setting



Blaikie and Kunzmann 2019

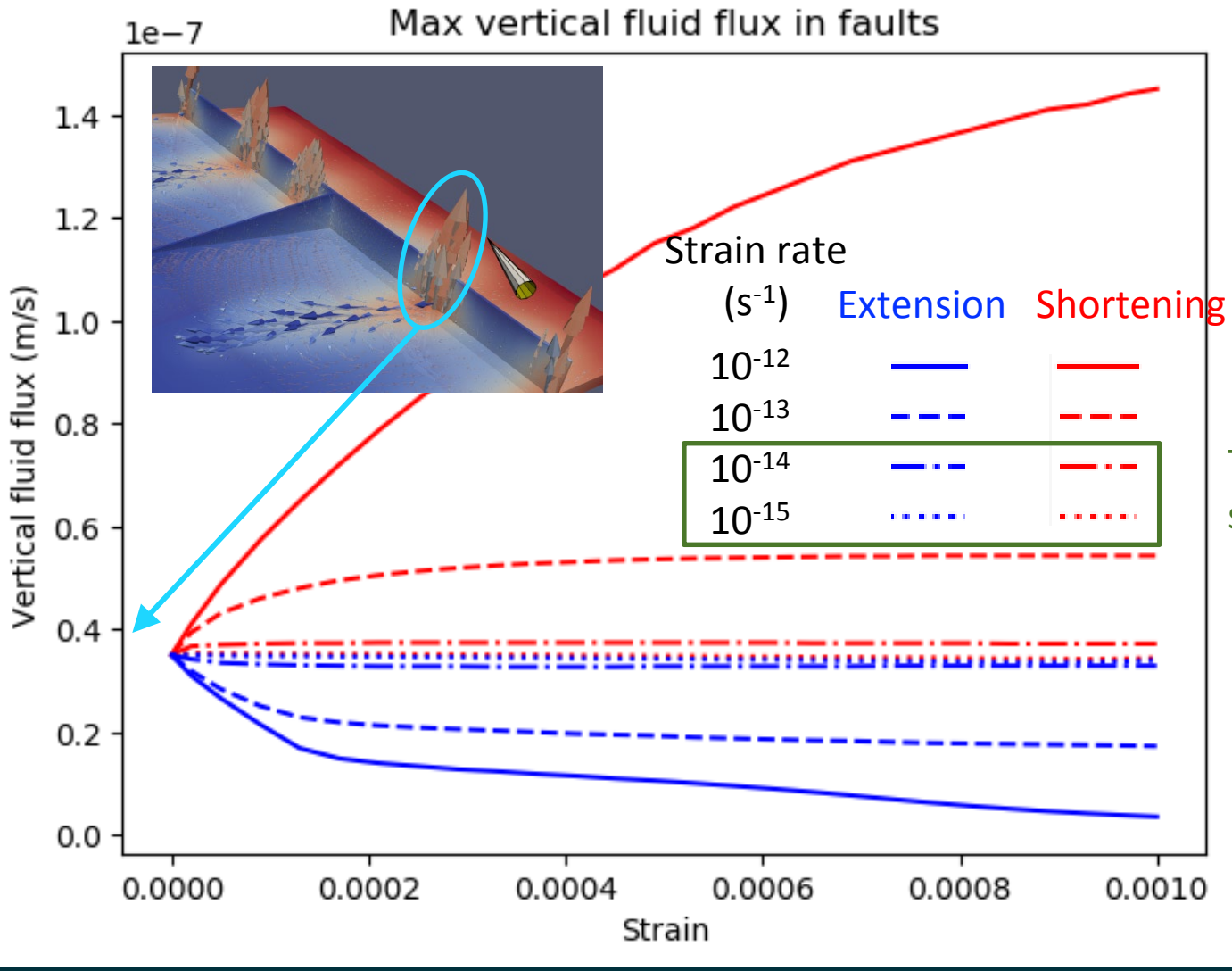
- Lower Barney Creek Formation deposited during North-South extension
- Inversion event ~1640 Ma, during deposition of upper BCF
- Mineralisation occurs in lower BCF
- Implications:
  - Syngenetic mineralisation occurred during extension
  - Diagenetic mineralisation occurred during extension OR inversion

Applying extension/shortening to the model



- Establish convection
- Apply north-south extension or shortening on boundaries
- Expected behaviour:
  - Extension draws fluids down
  - Contraction drives fluids up

Results: Effect of deformation on thermal convection



Typical geological strain rate

Conclusions

- Thermal convection created localised upwelling of hot metalliferous brine along the Emu Fault
- Syngenetic mineralisation (with minor early diagenetic mineralisation) occurred if Emu fault had high permeability to the seafloor
- Diagenetic mineralisation occurred if Emu fault had low permeability at shallow depths, with black shale acting as a seal
- Thermal convection provided sufficient fluid flux to account for mineralisation
  - < 1 million years for syngenetic mineralisation
  - > 1 million years for diagenetic mineralisation
- Deformation had minimal effect on thermal convection unless strain rates were anomalously high
- Future work should consider effects of:
  - Salinity
  - Large deformations leading to development of topography (fault scarps)
  - Variations in fault permeability with deformation

Thank you

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