Modelling fracture risk in topseal units

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Risk: Leakage through fractures in topseal

There is a risk of CO_2 leakage through the topseal, due to:

- Existing natural fractures which cut through the topseal
- Hydraulic fractures, driven by fluid pressure due to CO_2 injection

Risk: Leakage through fractures in topseal

Fractures are unlikely to nucleate within the topseal, because:

- Good topseal units are ductile – they have high horizontal stress
- Good topseal units have low permeability – so their fluid pressure does not change significantly when fluids are injected into the reservoir

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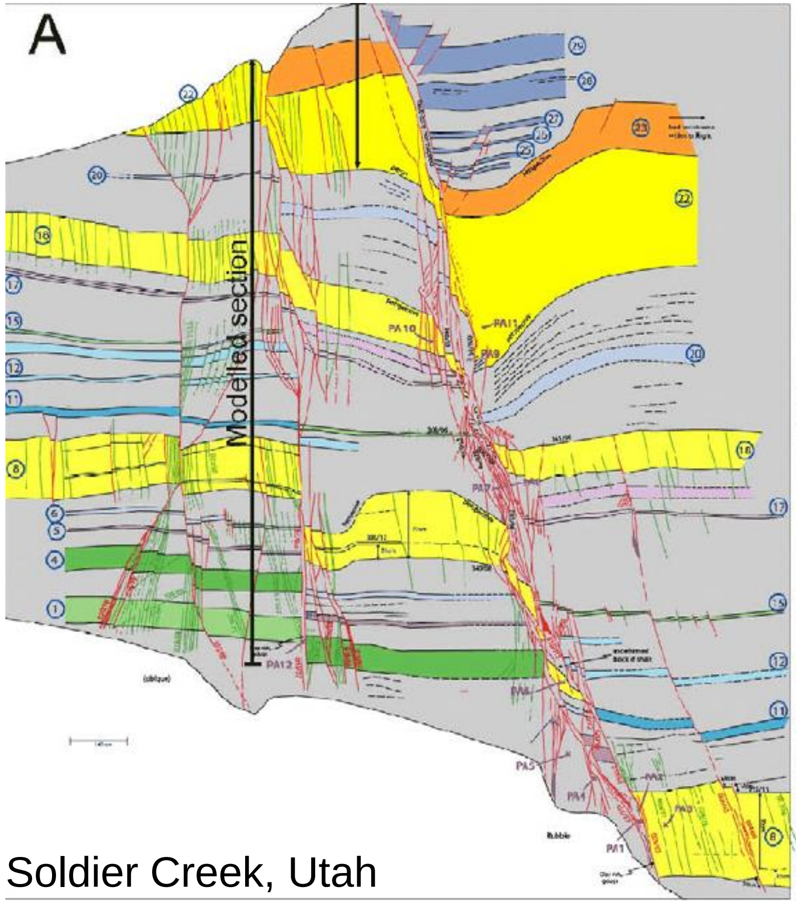
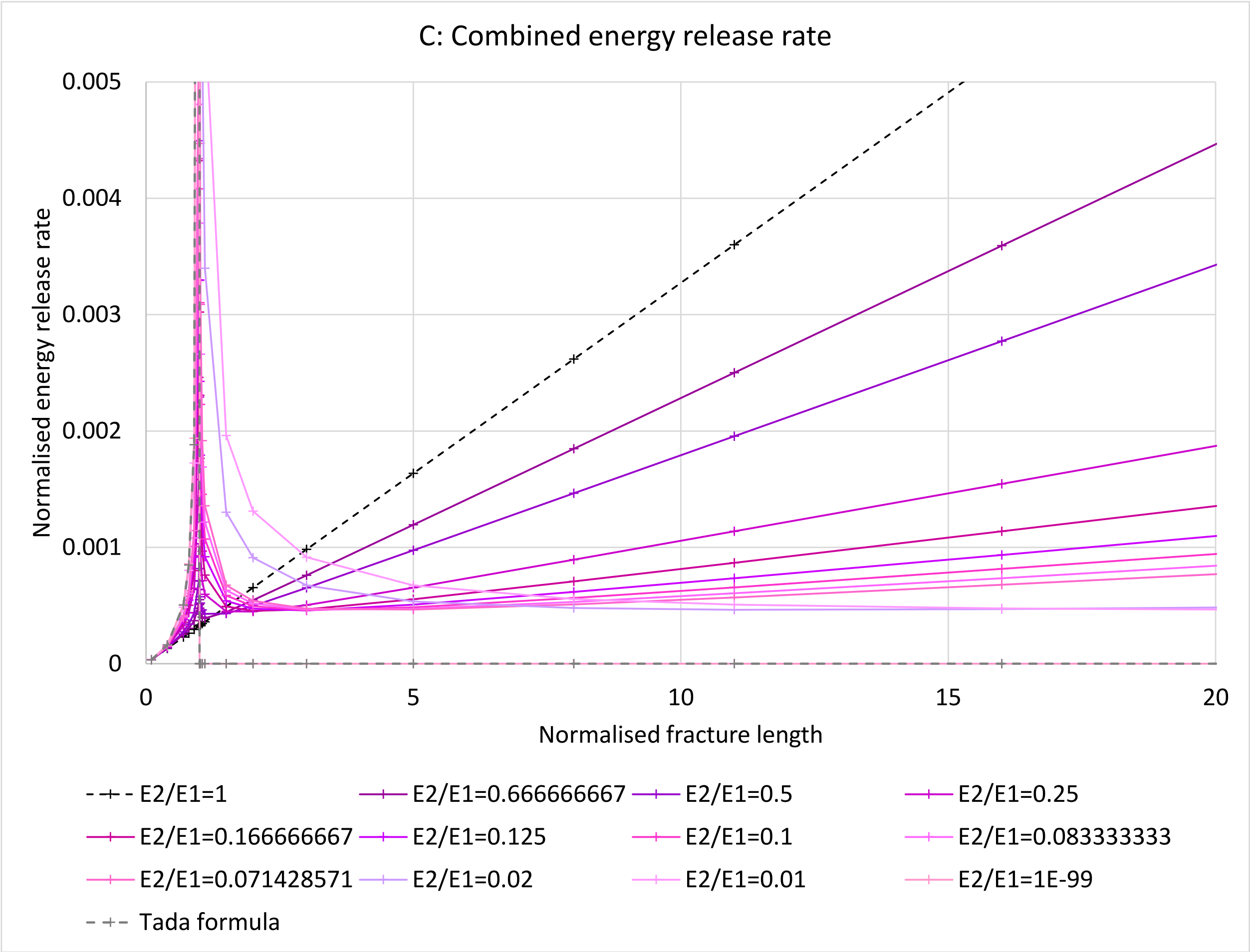


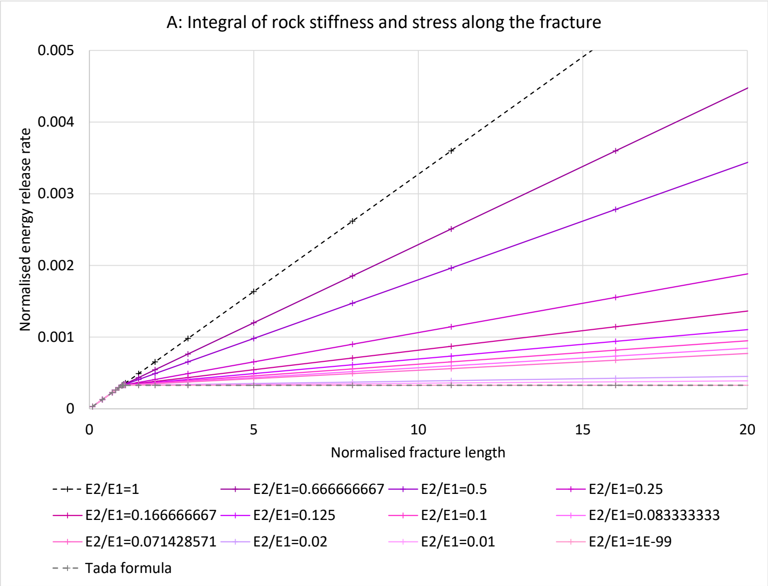
Soldier Creek, Utah

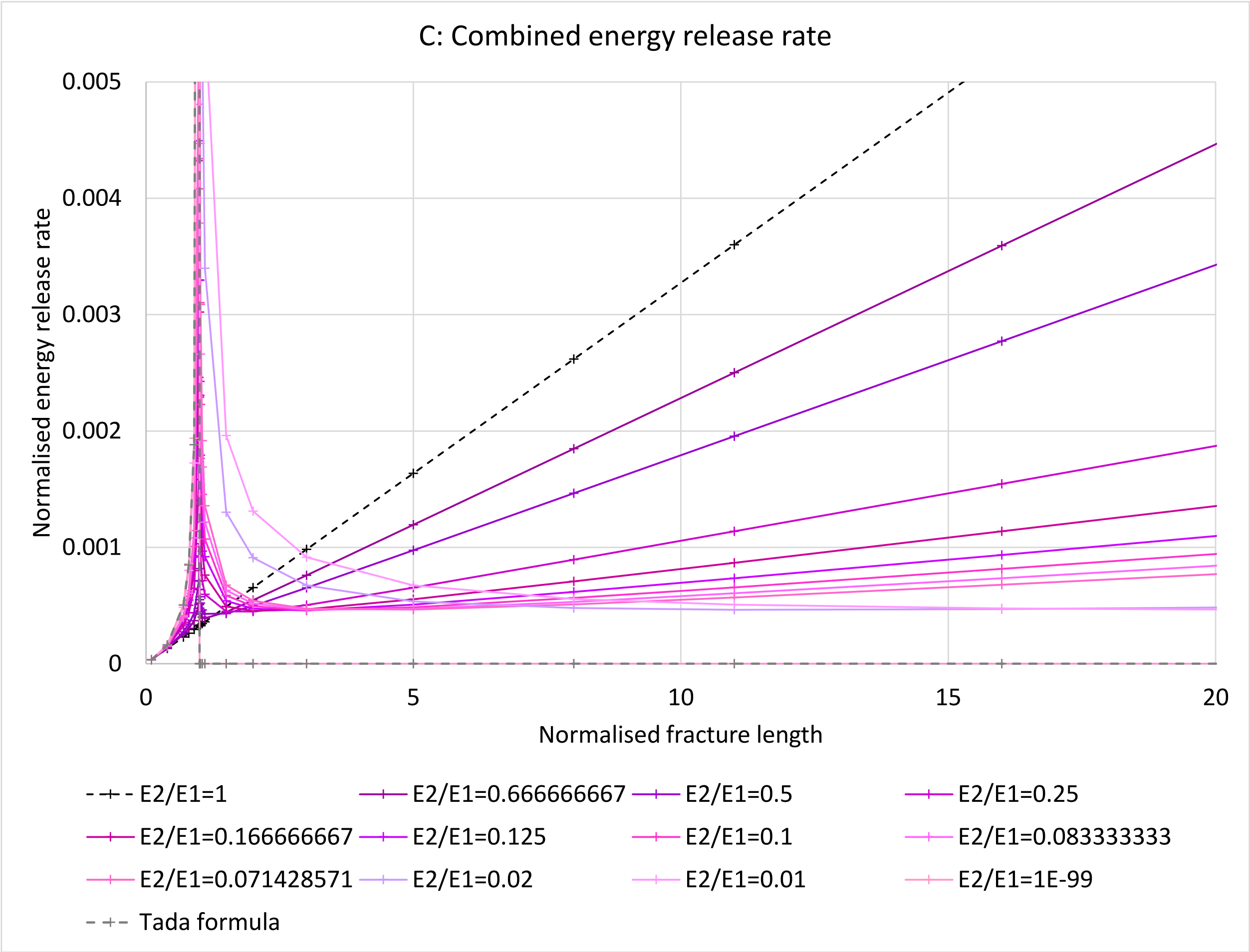
Modelling fracture propagation into topseal

- We have already developed an algorithm to model natural fracture propagation from a stiff reservoir into a compliant topseal, based on Linear Elastic Fracture Mechanics (LEFM)
- This is based on the energy release rate. The fracture propagation rate is dependent on the energy release rate / the crack surface energy of the rock
- The energy release rate as the fracture propagates into the topseal can be split into two components:
  - A base component, proportional to the rock stiffness and fracture length
  - A boundary component due to the mechanical interface



Modelling fracture propagation into topseal





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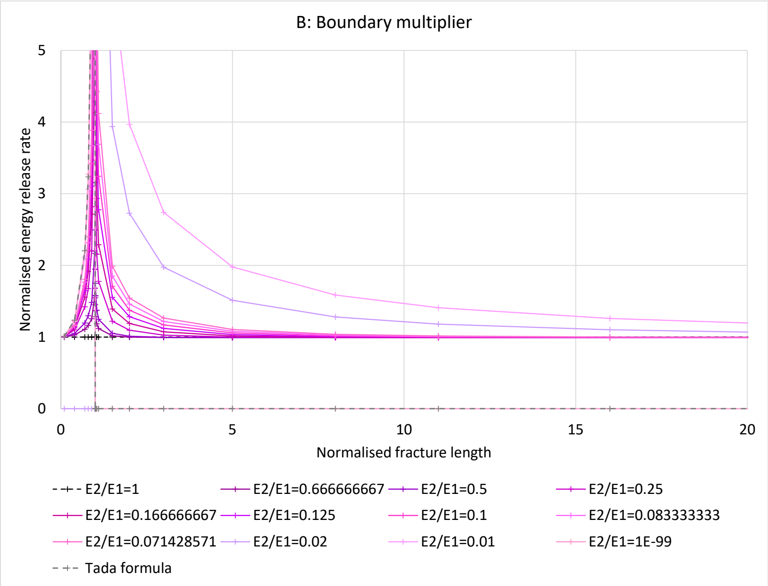

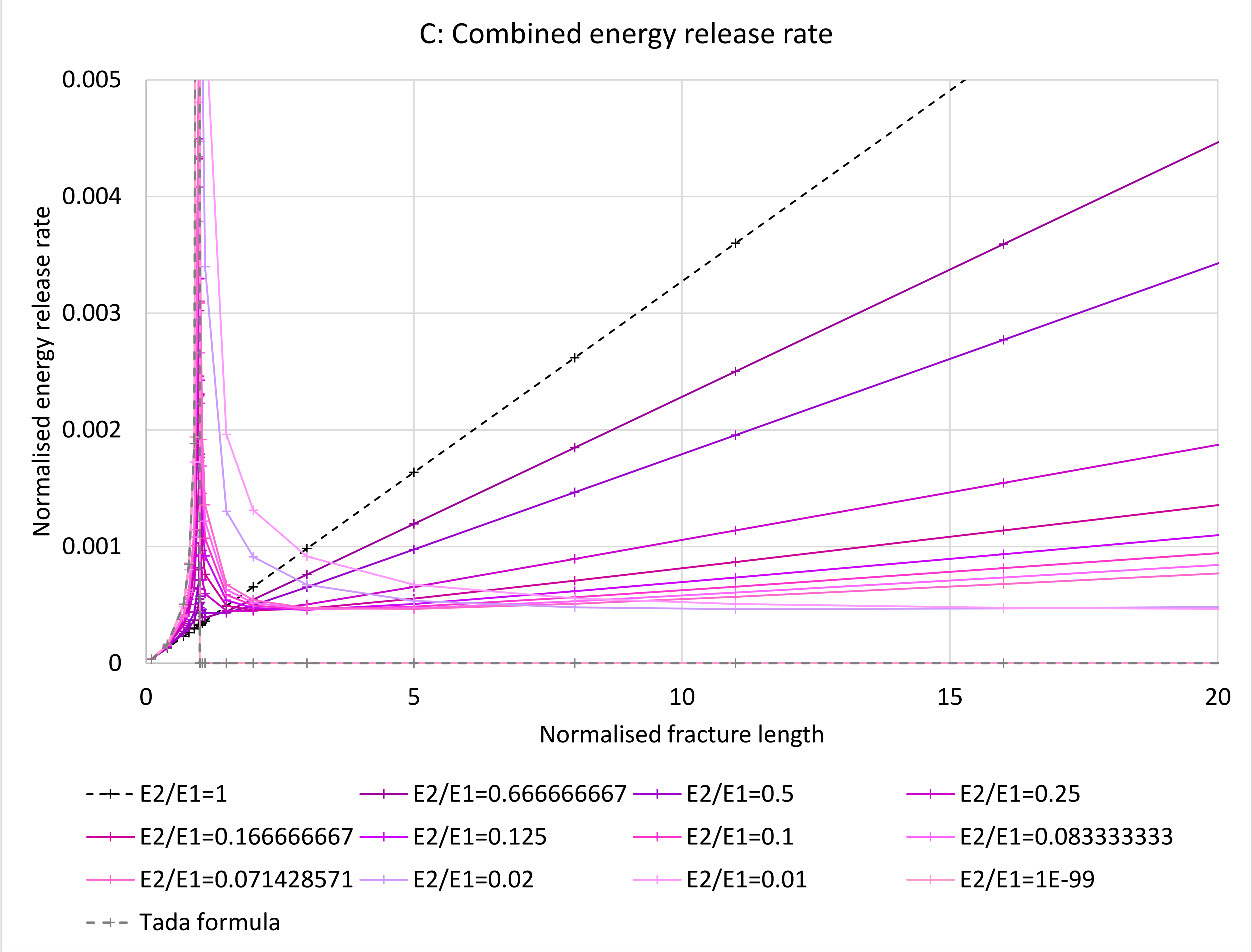

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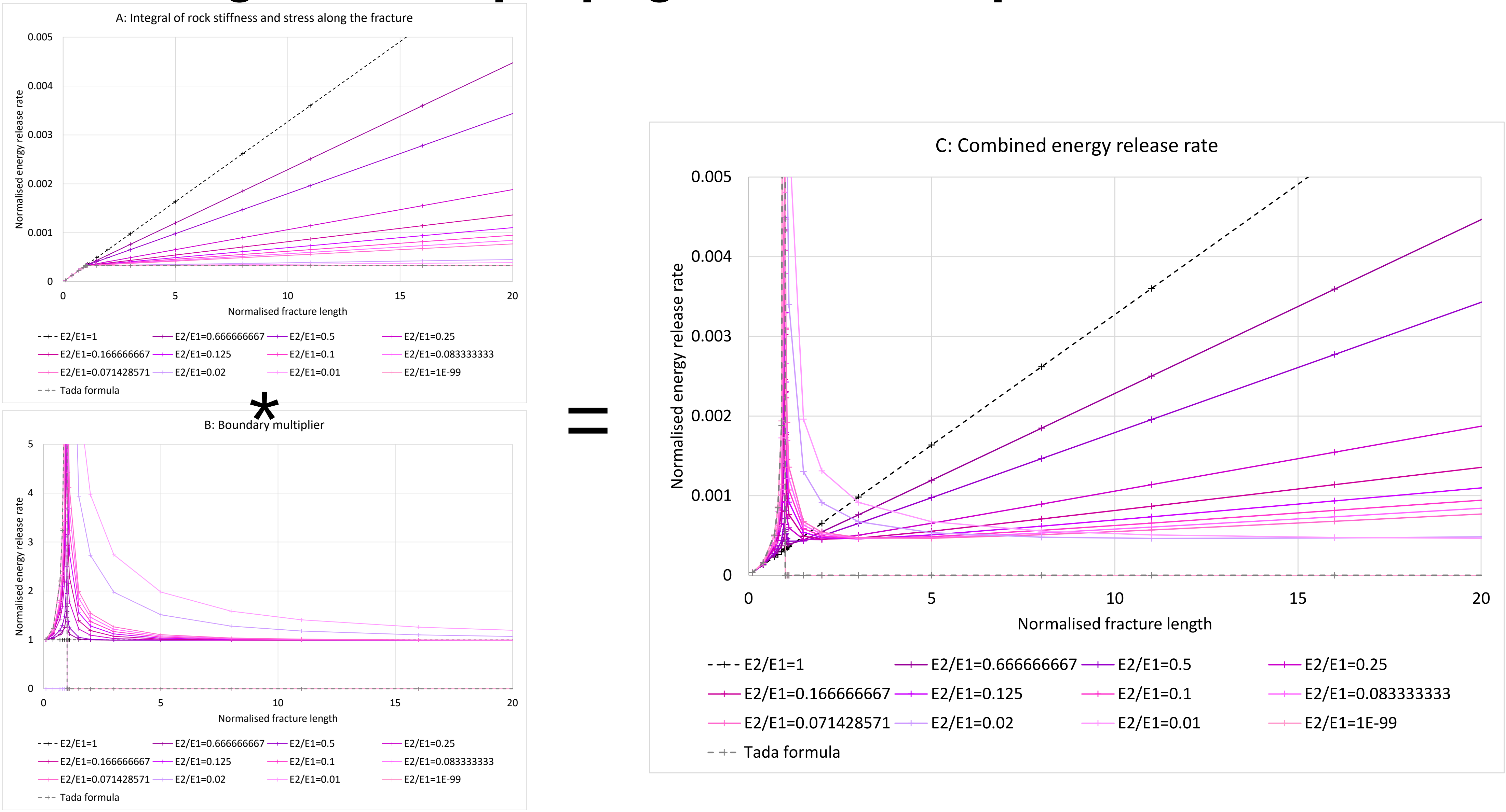
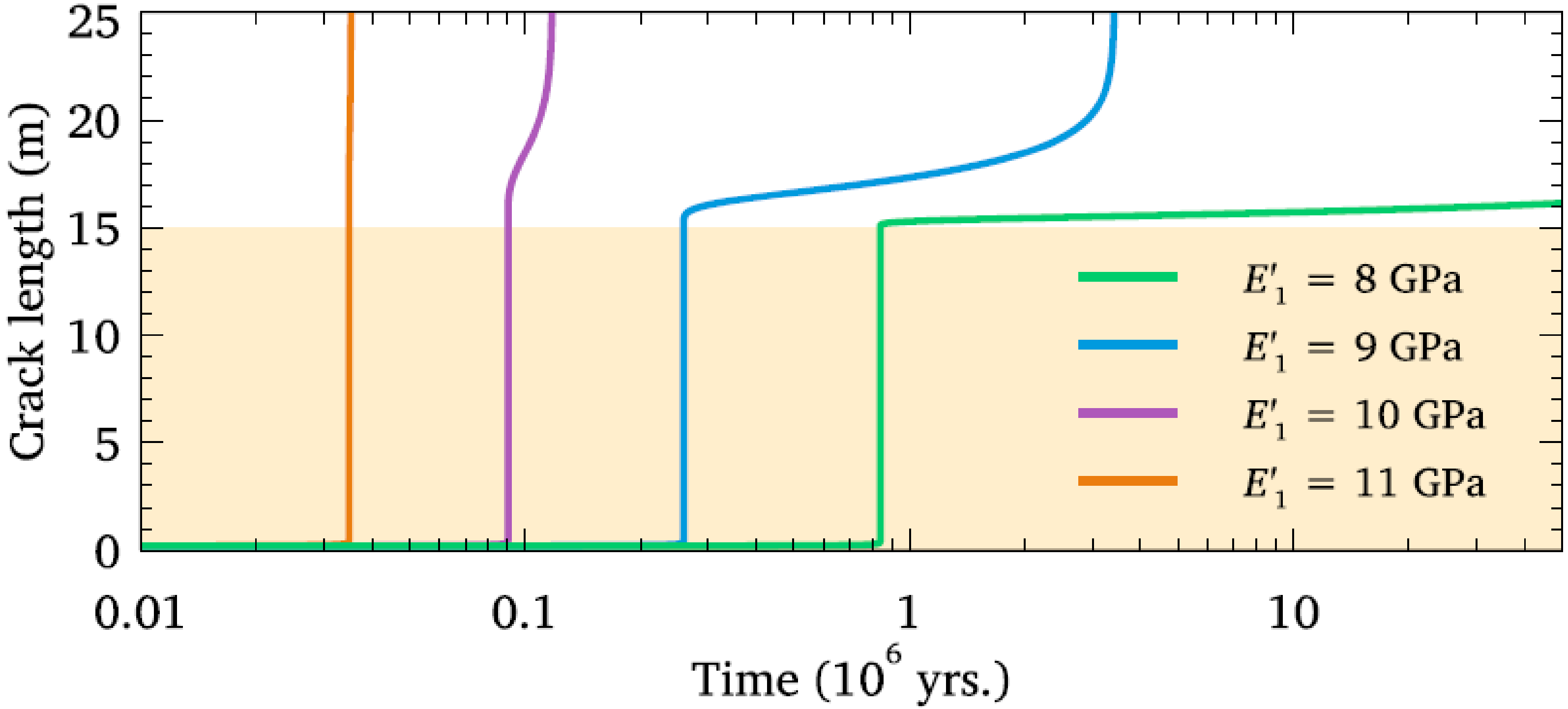


Modelling fracture propagation into topseal

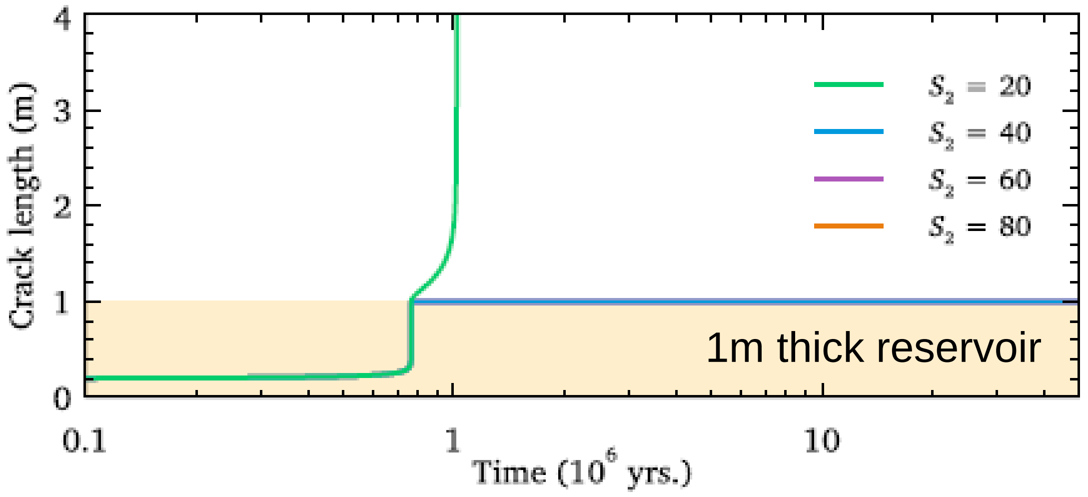
- As a fracture reaches the top of the reservoir, it may either:
  - Propagate immediately into the topseal – no effective mechanical boundary
  - Arrest temporarily at the mechanical boundary
  - Arrest permanently at the mechanical boundary



Controls on fracture propagation into topseal

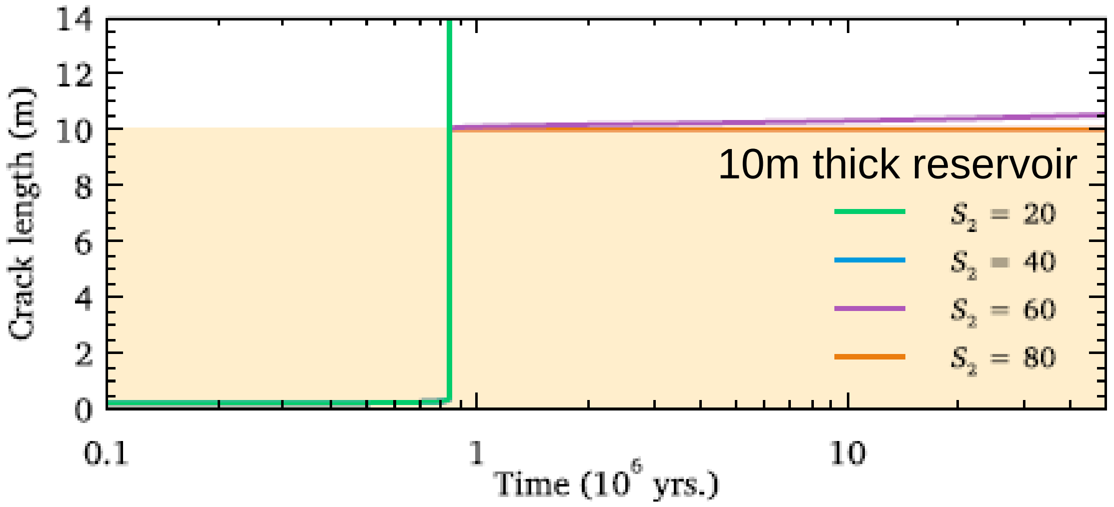
The fracture is more likely to propagate into the topseal if

- The reservoir layer is thin
- The subcritical index of the topseal is low
- The crack surface energy in the topseal is low



Other factors include:

- Strain rate
- Stiffness contrast across the boundary



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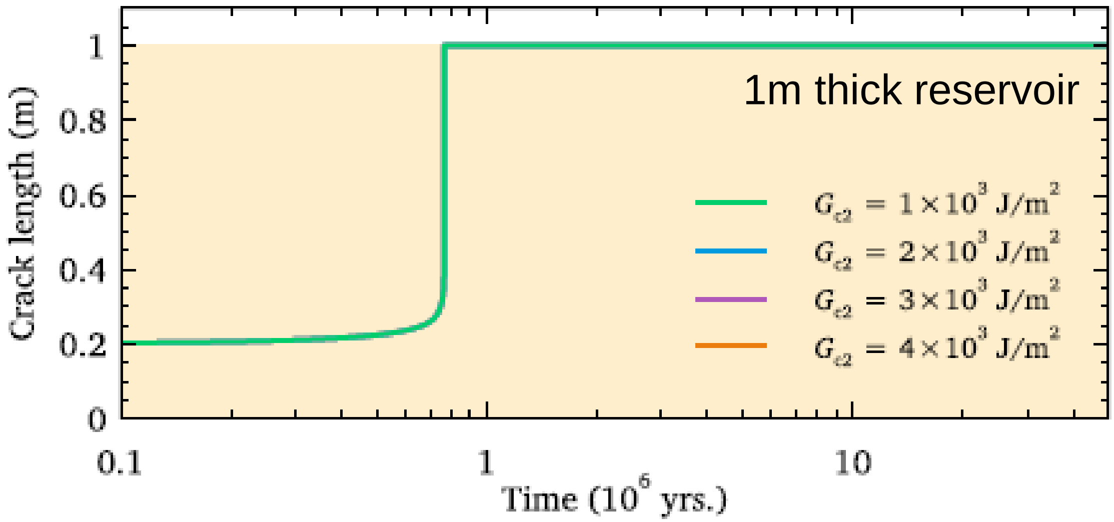
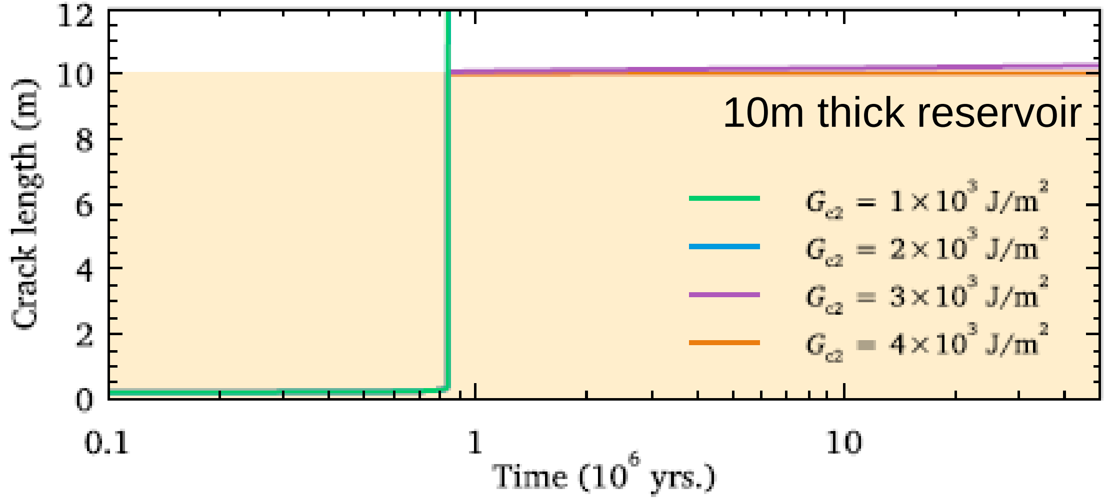
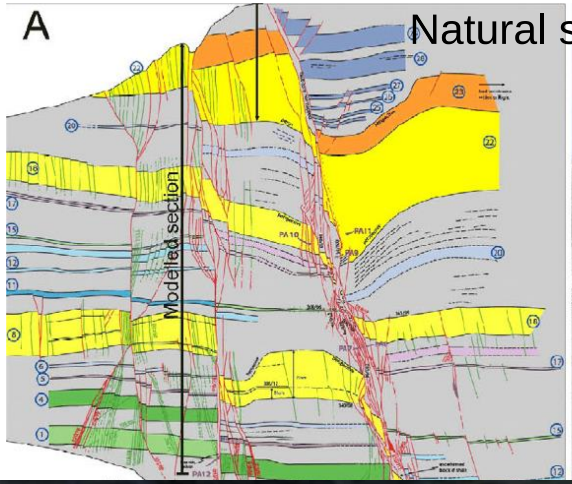


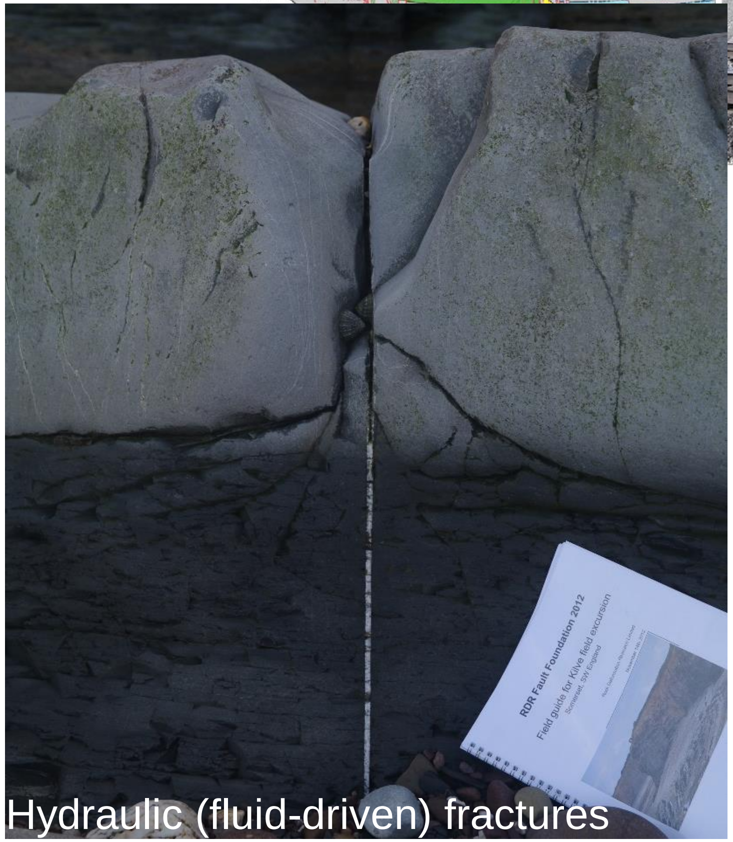


Natural vs hydraulic fractures

- These models assume uniform strain-driven fractures. This is the case for natural fractures.
- For hydraulic fractures, the driving stress will be uniform.
- We have not developed a model for the boundary effect in this case.
- However we can calculate the base component energy release rate as the fracture propagates into the topseal.



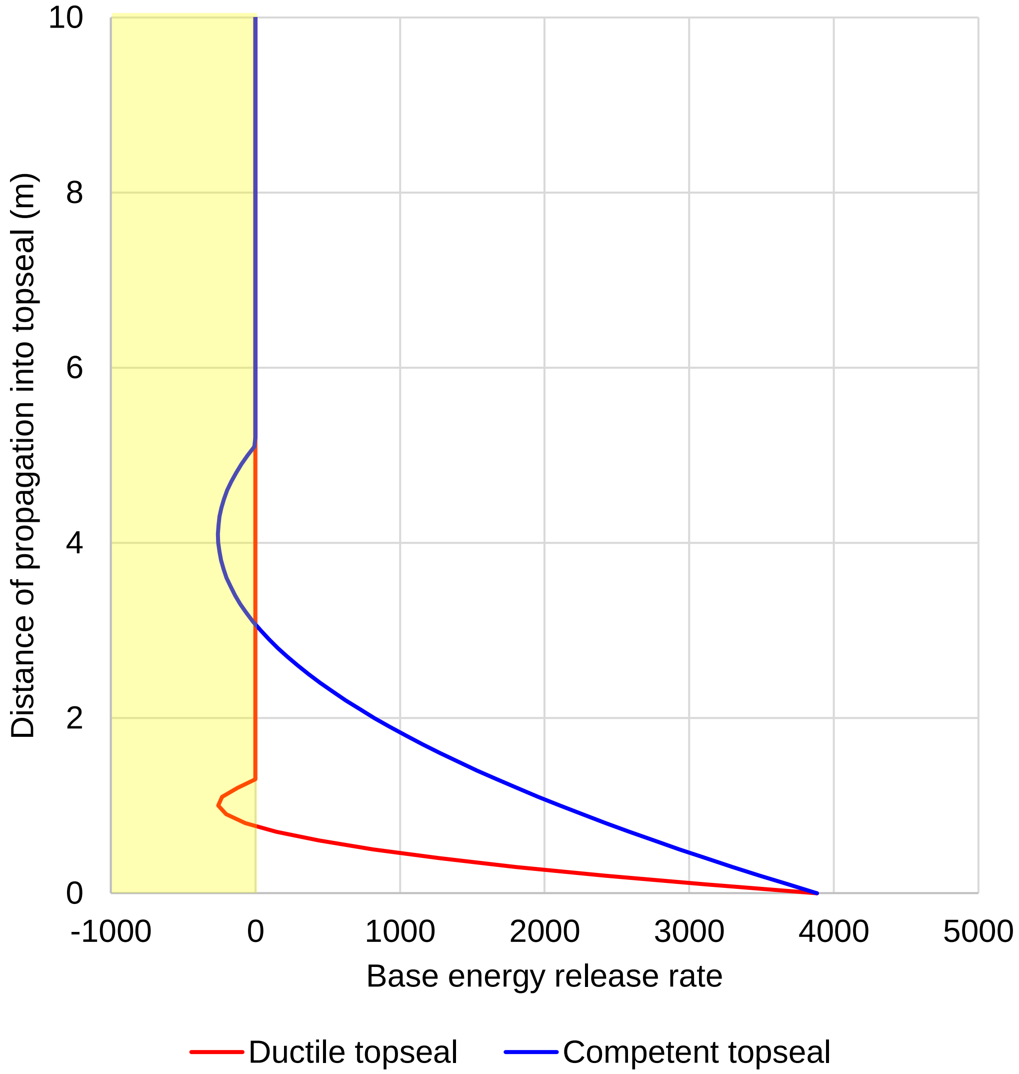
Natural strain-driven fractures



Hydraulic (fluid-driven) fractures

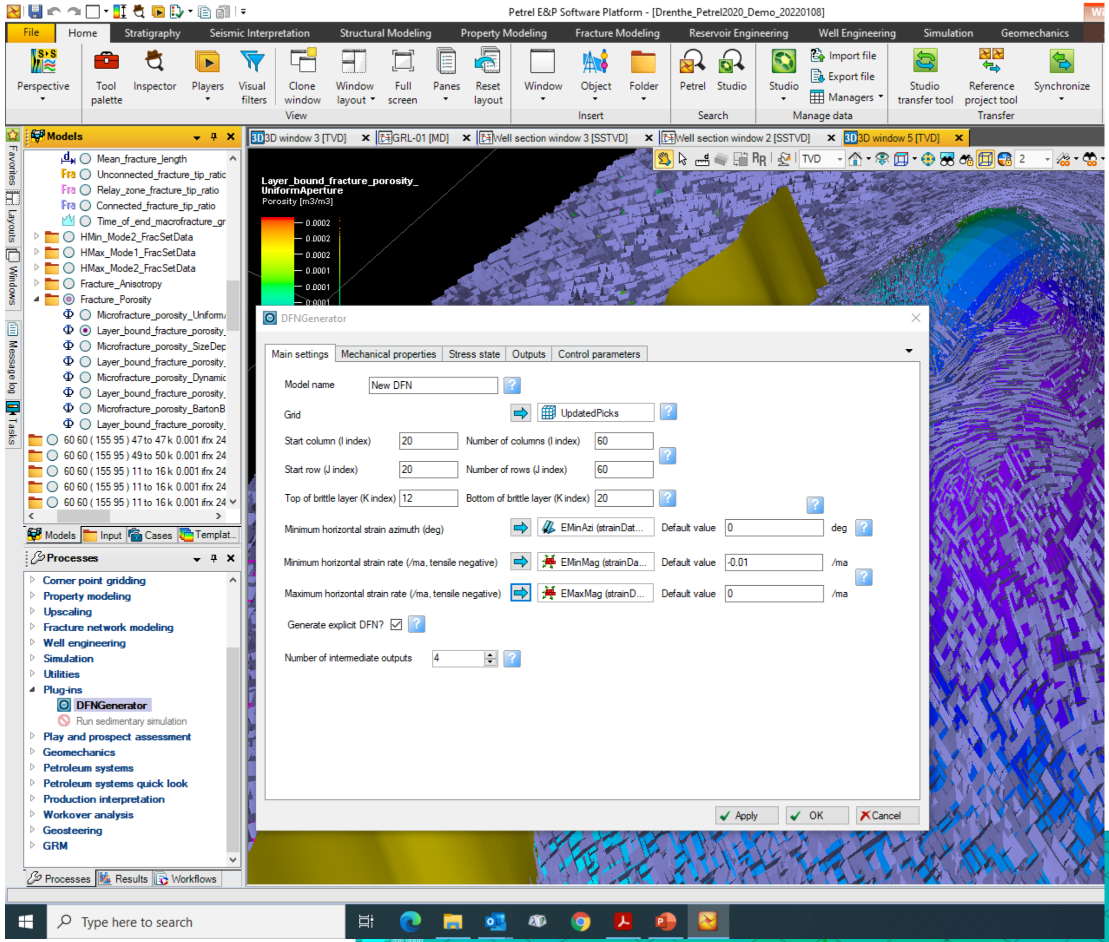
Hydraulic fracture propagation into topseal

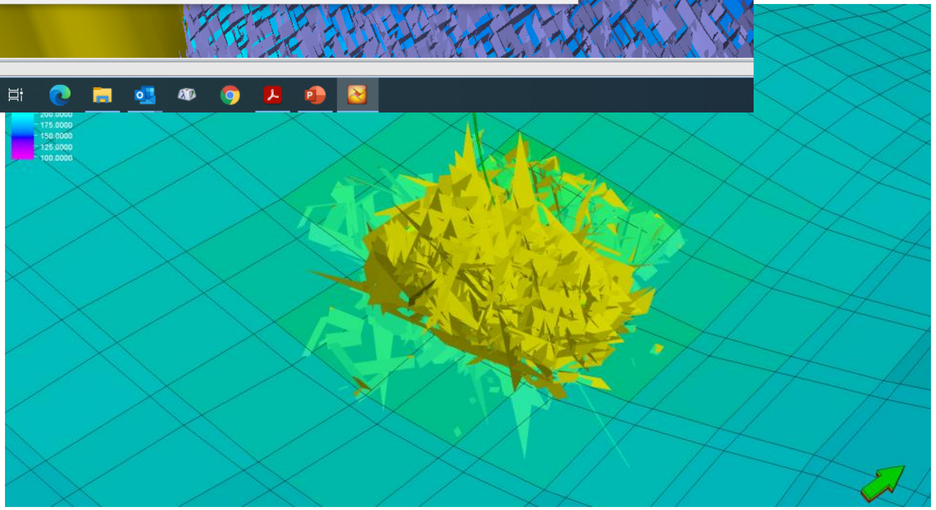
- In general, the energy release rate drops rapidly as the fracture propagates into the topseal, if the topseal is very ductile (horizontal stress is high)
- When the topseal is more brittle, the fracture can propagate further
- More work is needed to constrain the algorithm, and to add the boundary effect



Petrel plug-in

- We have already released a Petrel plug-in to build fracture models within the reservoir
- This is available as open source software from https://gitlab.gbar.dtu.dk/offshore/dfm-generator
- This can also be coupled with Visage and Eclipse to model fluid-driven fractures in the reservoir
- We have developed a version to model natural fracture propagation into the topseal; however this has not yet been released
- We would like to develop a version to model hydraulic fracture propagation into the topseal; however this will require further work





Please come and see the software demo in the poster room