Modelling large-scale fractured reservoirs efficiently for geothermal energy and groundwater flow

Simon Oldfield[1], Mikael Luthje[1], Michael Welch[1] & Florian Smit[2]

[1] DHRTC, Technical University of Denmark
[2] University of Copenhagen

Introduction

Using a geothermal prospect in the Drenthe Province, Netherlands we generate a discrete fracture network over several square kilometers to understand the potential influence of fracturing in the Upper Cretaceous.

Recent work has shown that the high thermal conductivity of salt can provide favorable targets for geothermal exploration (Daniilidis & Herber, 2017). We consider the likelihood of fracturing of the Upper Cretaceous above the Anloo salt diapir.

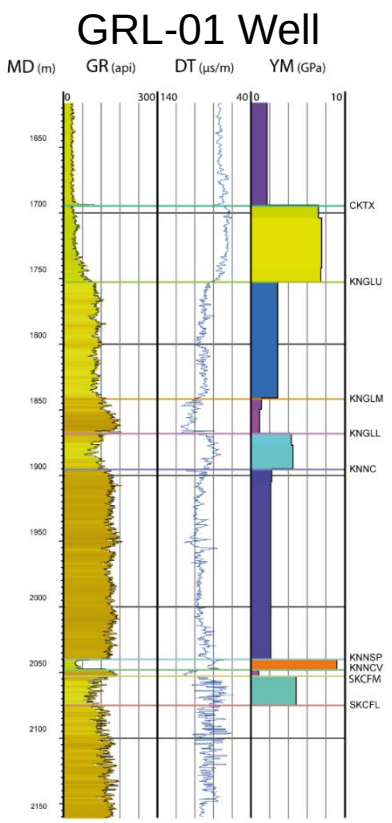
This area is covered by a large 3D seismic volume and extensive surface studies by the Horizon 2020 TOPSOIL project. Building on the work of Smit et al. (2018), we consider the relationship between shallow and deep hydrological systems, by integration of a new aerial EM survey and fracture modelling of the area.

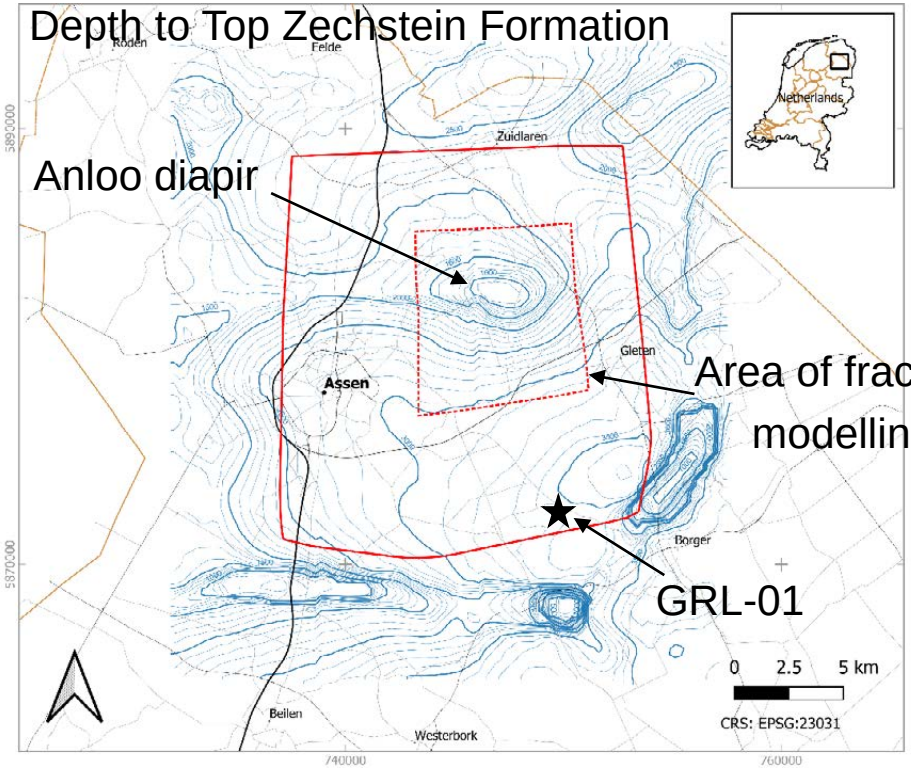
We are actively seeking collaborators from the hydrogeological and geothermal communities to develop this work further.

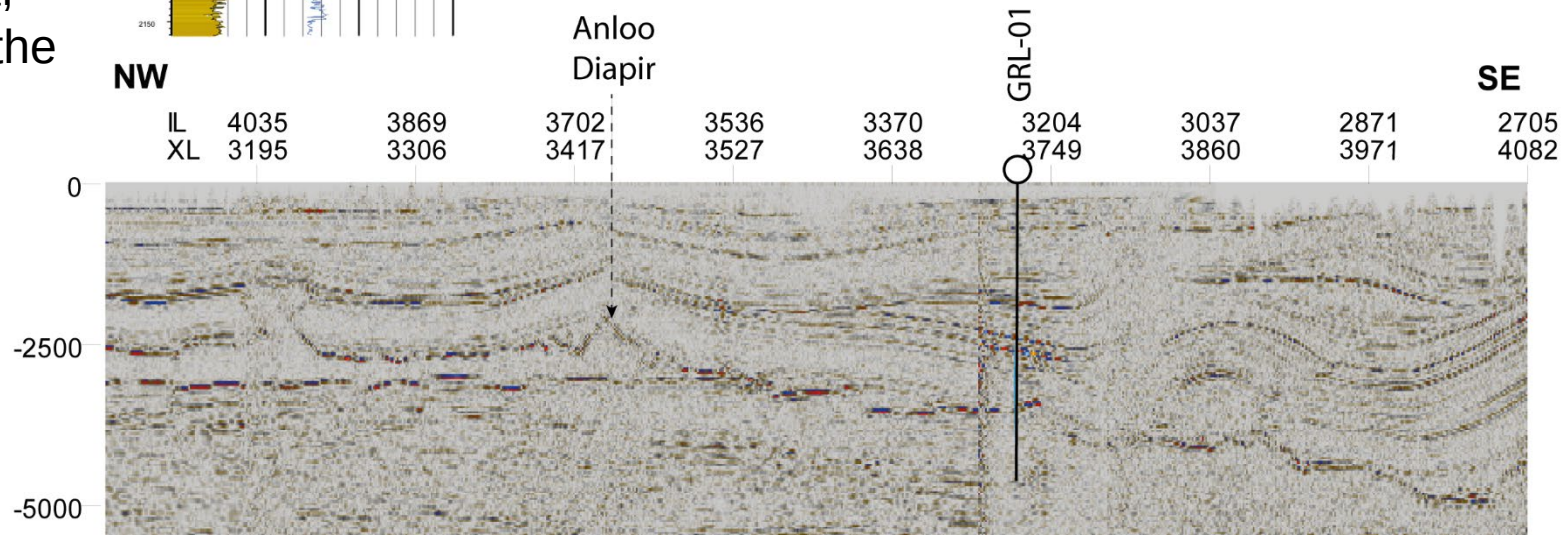
Location

The Anloo Salt Diapir is located within Drenthe Province, NE Netherlands.

Underlain by formations previously targeted by hydrocarbon exploration, and overlain by the Drenthe Aa, rich datasets exist of both the subsurface and landscape above.



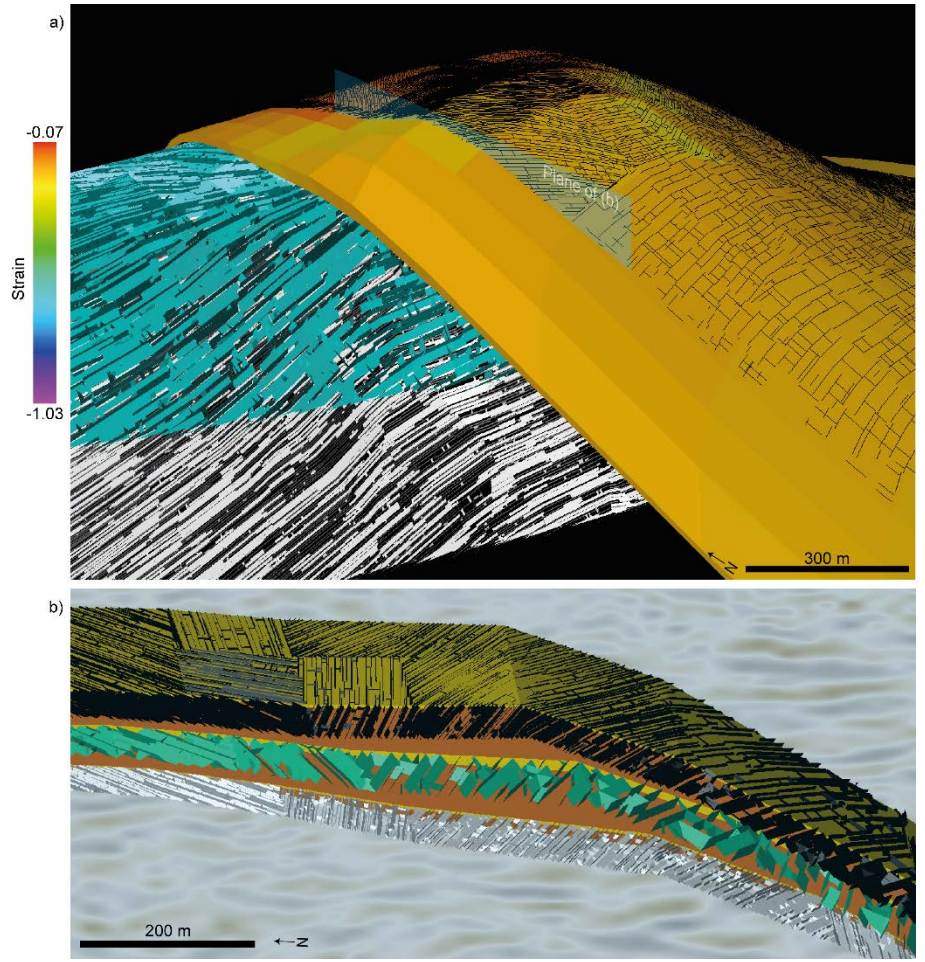




Fracture modelling

Using mapping by TNO (Hummelman et al., 2019) to provide constraint on subsurface geometry, we use calculate the strain tensor using a pseudo-3D backstripping approach by K. Petterson (pers. comm.).

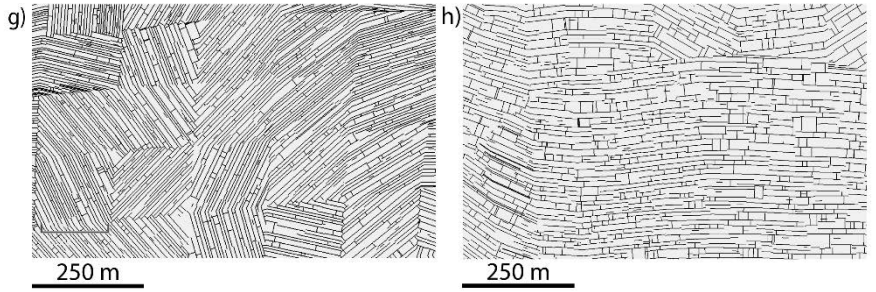
These strain tensors are then used with basic calculations of the stress history to apply the approach of Welch et al. (2019) for fracture modelling of three stratigraphic intervals (Texel Fm., Lower Holland Fm. & Vlieland Sandstone Fm.).

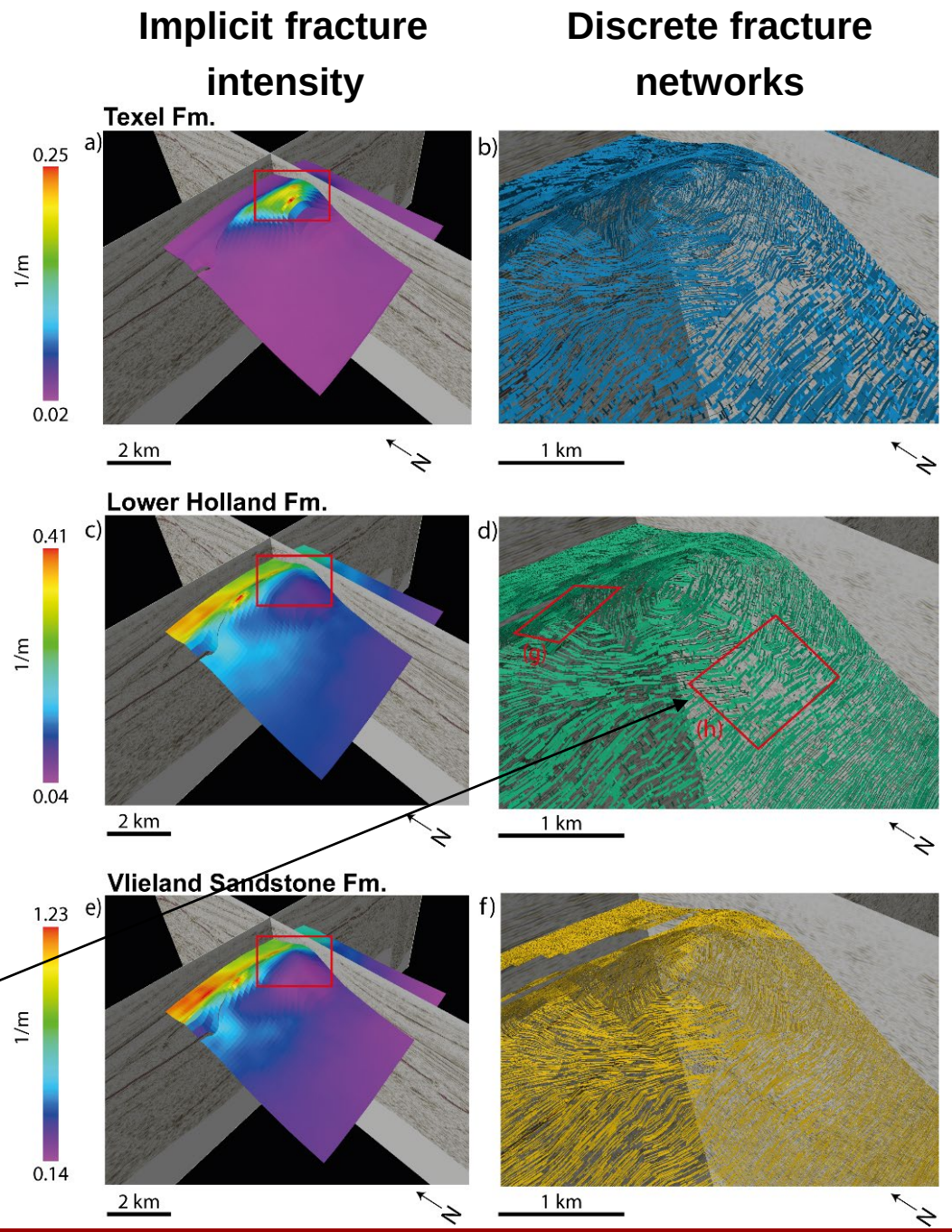


Fracture modelling

Discrete fracture networks (DFNs) and implicit fracture mapping for three intervals are calculated for an area of 16 square kilometres.

Multiple scenarios are calculated to enable comparison with other data sources. The modelled fracture anisotropy and intensity (below) suggest that fluid flow is likely to be guided by fractures in the Upper Cretaceous.



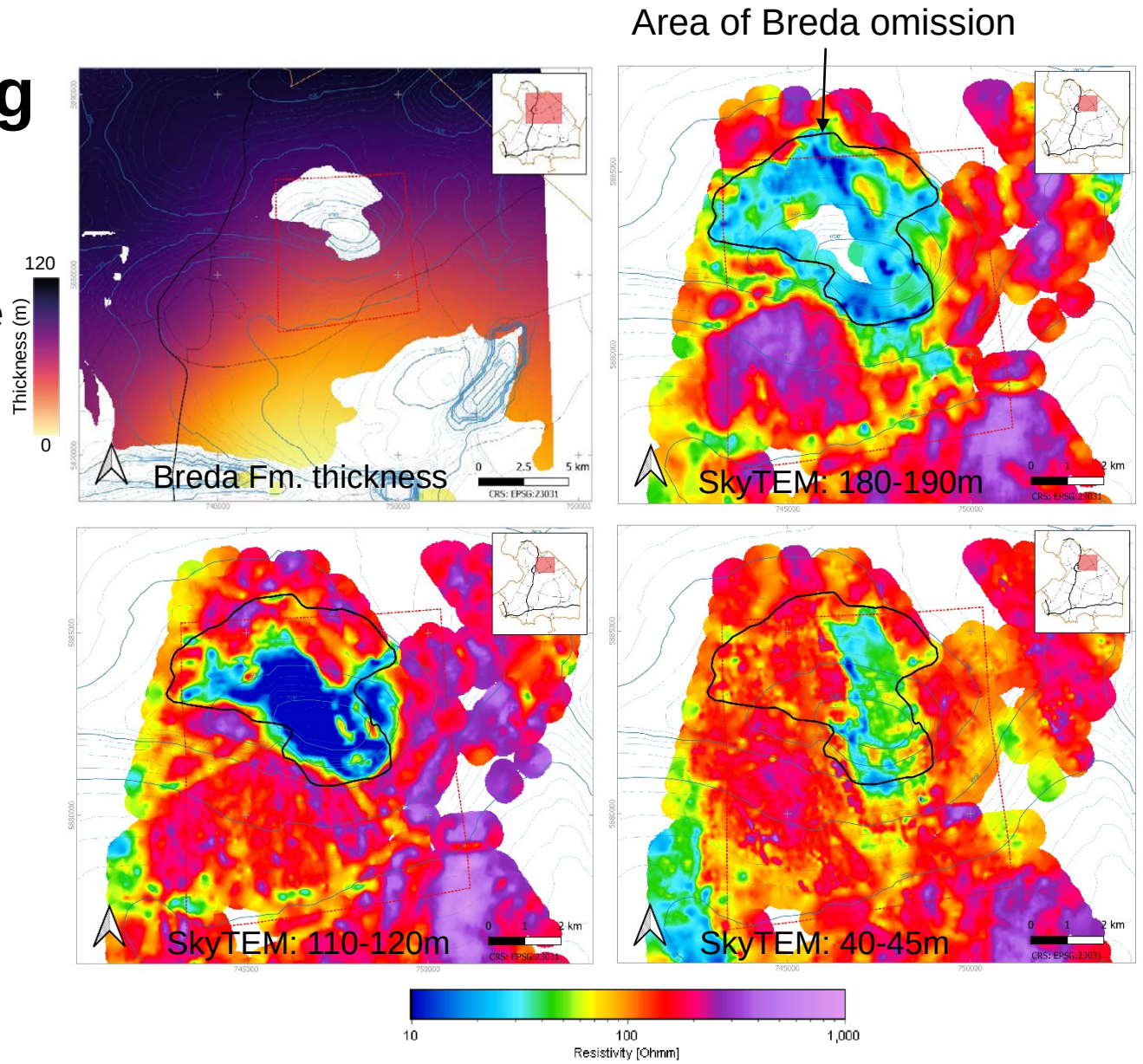


Seal isochore mapping

Isochore mapping of the Breda Formation, a regional seal, shows that it is omitted from the stratigraphy above the Anloo salt diapir.

Comparing the outline of this area of omission, shown in black, over the results of recent airborne SkyTEM surveying shows that reductions in resistivity are observed over the salt diapir.

Resistivity anomaly at depth correlates to sub-cropping salt.

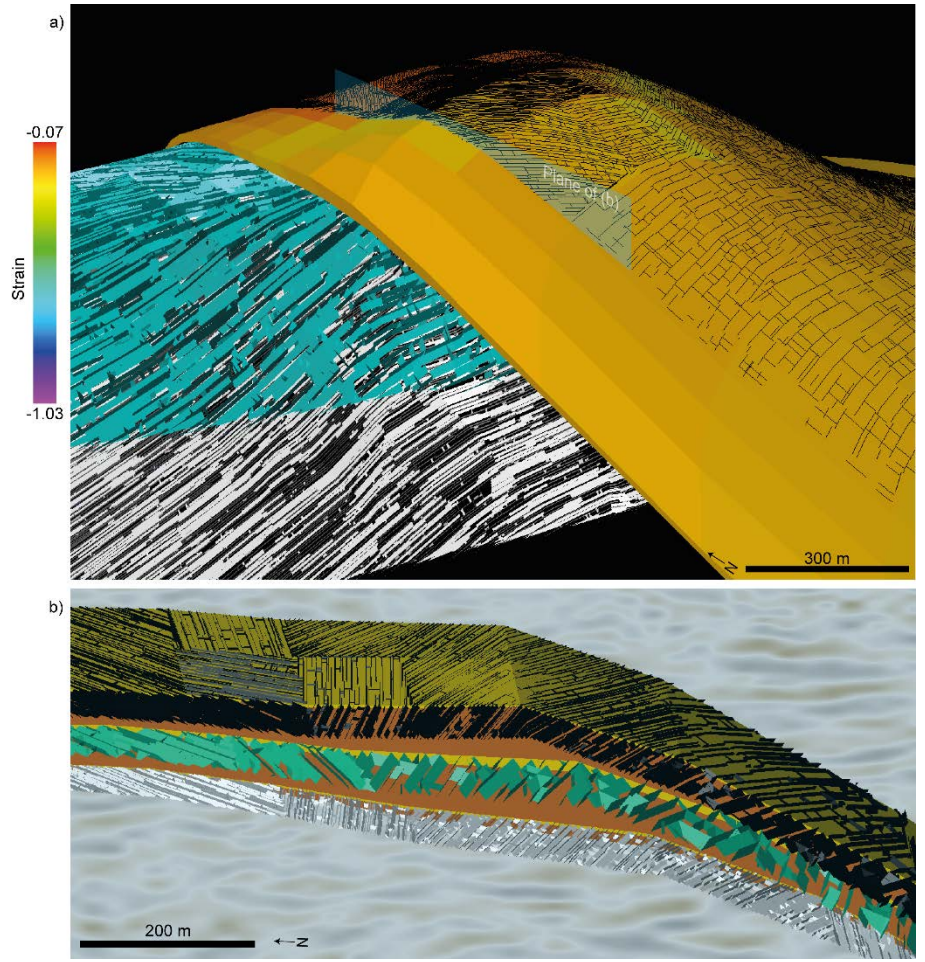


SkyTEM survey courtesy of HydroGeophysics Group, Aarhus University with permission from Province Drenthe

Discussion

- Resistivity anomalies suggest increased conductance above the Anloo diapir
- This implies chemical transport from below both a regional seal, the Breda Formation and the Upper Cretaceous
- Mapping of the Breda suggests it is absent below the elevated conductivity
- Fracture modelling of the Upper Cretaceous suggests that fracturing is likely to influence groundwater movement

We would like to collaborate to generate a flow model to consider how fracture properties could influence groundwater, salt transport and heat flow.



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