

Fastflo in Geophysical Modelling

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What is Fastflo

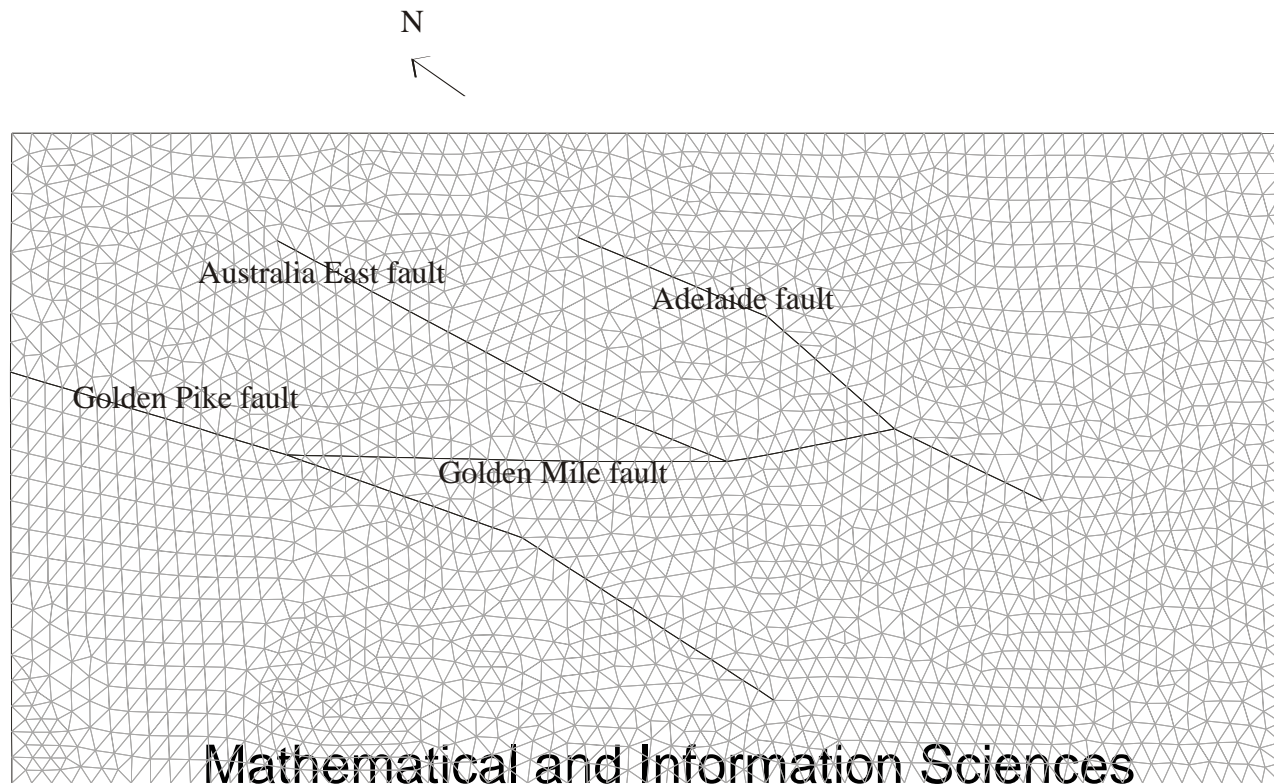
- *Fastflo* is a finite element based solver for partial differential equations, developed by CSIRO and marketed world-wide
- *Fastflo* is especially useful for problems with complicated geometry and physical processes
- Within one package, *Fastflo* can track coupled geophysical processes.

Modelling Approach

- CSIRO DEM and CMIS have been collaborating for some time to develop models in *Fastflo*, initially to express complex chemistry, but now to couple flow, elasticity and chemistry.
- The modelling done here is intended only as an indication of what may be possible; it is based on some real data, but scenarios are not realistic at this stage.

A domain with cracking

- The following diagram shows a region of the Golden Mile region with some major fault lines.



Fluid Flow

- The flow is assumed to satisfy Darcy's equation:

$$\nabla \cdot (\mathbf{K}_s (\nabla p - \rho \mathbf{g})) = -\eta \nabla \cdot \mathbf{v}$$

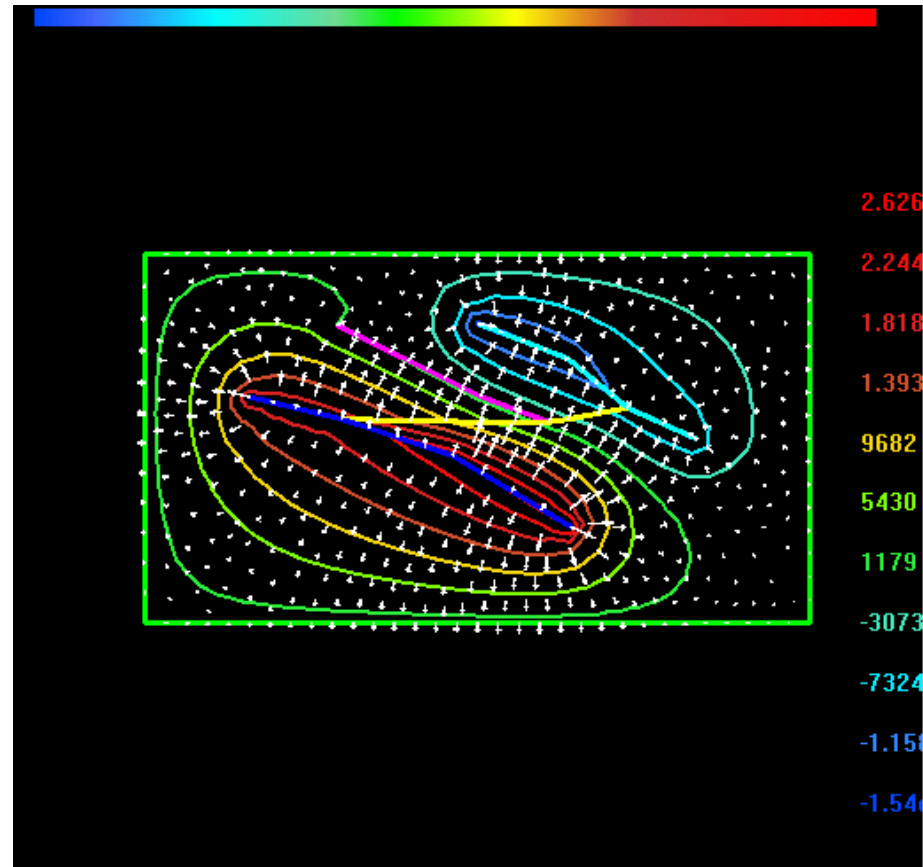
with a corresponding equation in the fault, and mass conservation of fluid.

- The permeability may vary with rock type, or with any prescribed spatial distribution
- The permeability may also vary within faults.

Fluid Flow

- In these results one fault (GPF) is assumed to be a net source of fluid, and one (Adelaide) a sink:.
- The plot shows contours of pressure and arrows of liquid flux

Fluid Flow

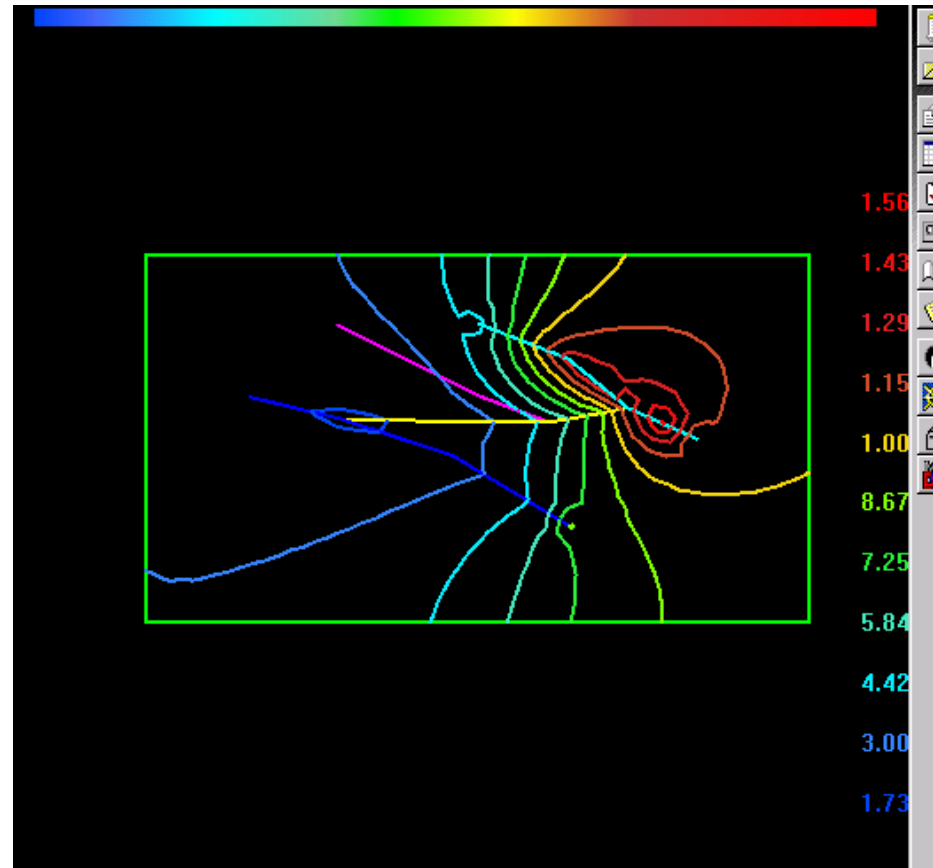


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Fluid Flow and mass transport

- Dissolved species (C) can also be easily tracked:
- $\nabla \cdot (1/Pe \nabla C) - \mathbf{v} \cdot \nabla C = 0$
- In the next slide, a region within in a fault acts as a source. There is an extra parameter to consider - the Schmidt number, giving the balance between convection and diffusion.
- The species C has a source in the purple (Australia East) fault

Fluid Flow and mass transport



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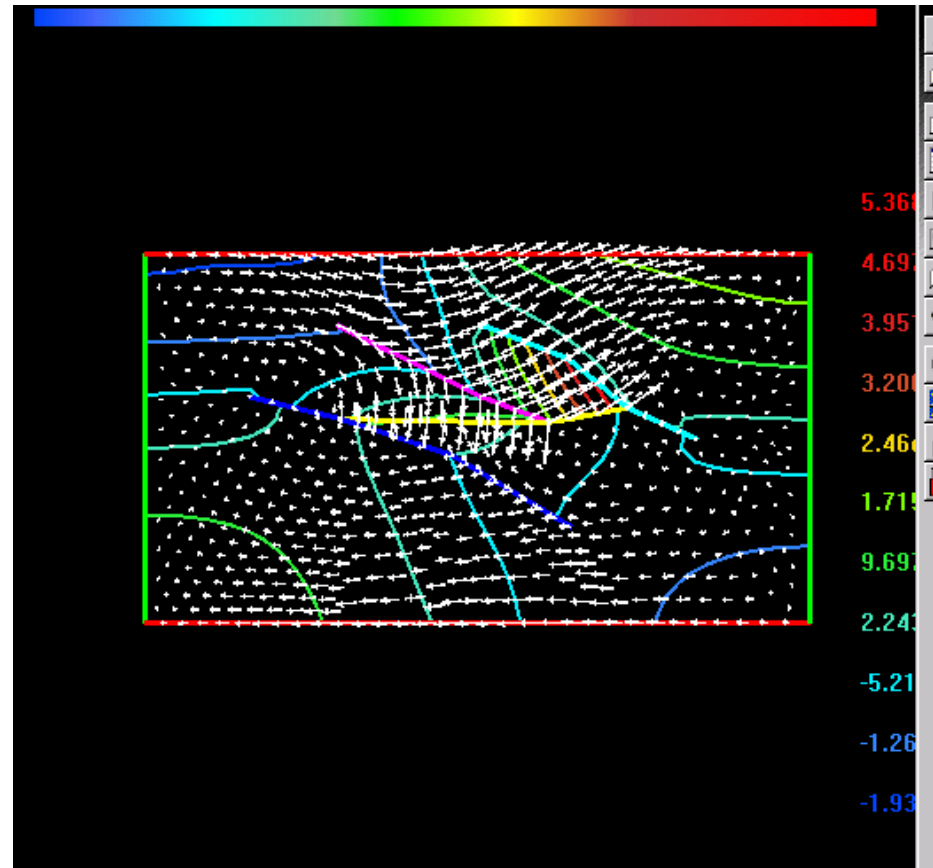
Fluid Flow and mass transport - comments

- At this moderate Schmidt Number, the species C is partly advected in the fault system, and also diffuses through the rock. Note the concentration maximum where the fault-borne flux emerges in the Adelaide (right) fault.

Stress-strain

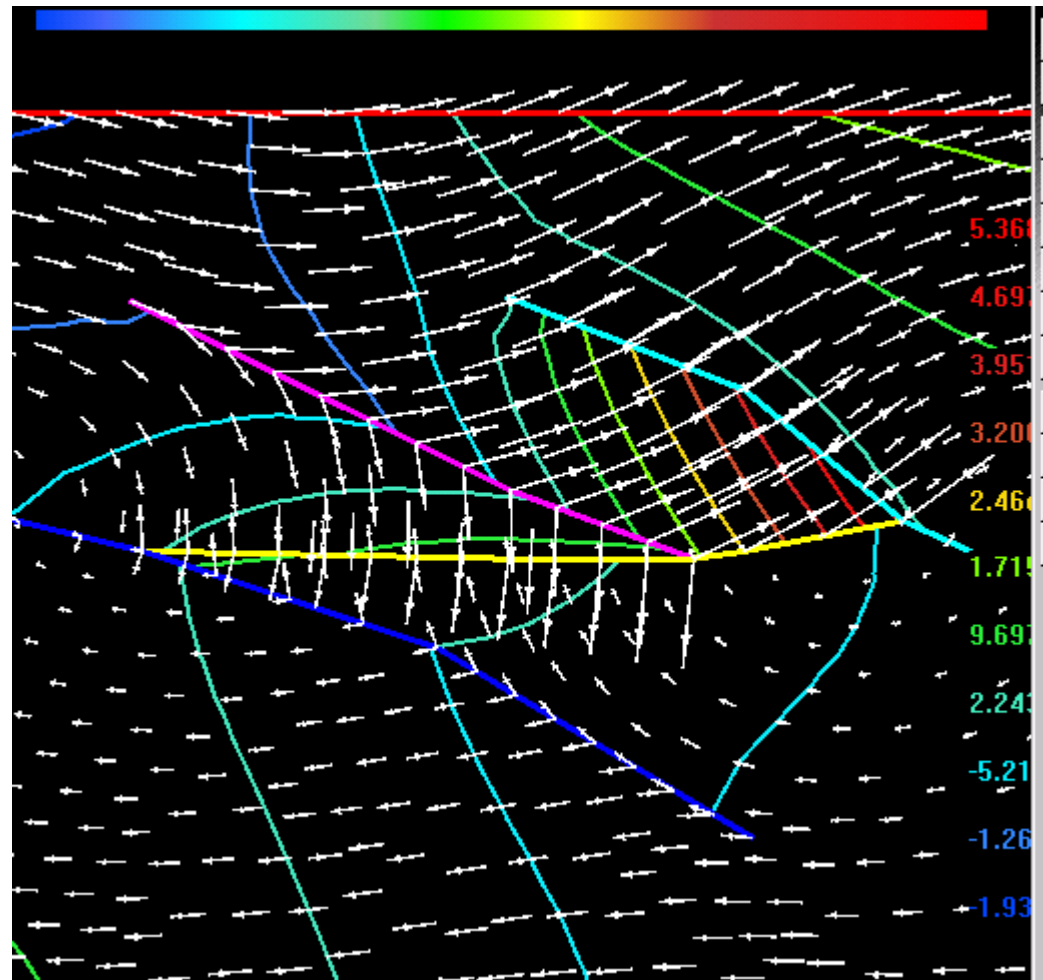
- Linear elasticity is assumed at this stage. With the assumption of uniform rock properties, and a shear applied across the region, and assuming that all the faults are free to either expand or contract, the displacement vectors are shown in the next slide
- To make the pattern clearer, the trace of the stress is also plotted. This acts somewhat like a pressure, and the displacements approximately follow the downward gradient

Stress-strain - displacements



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Stress-strain - detail

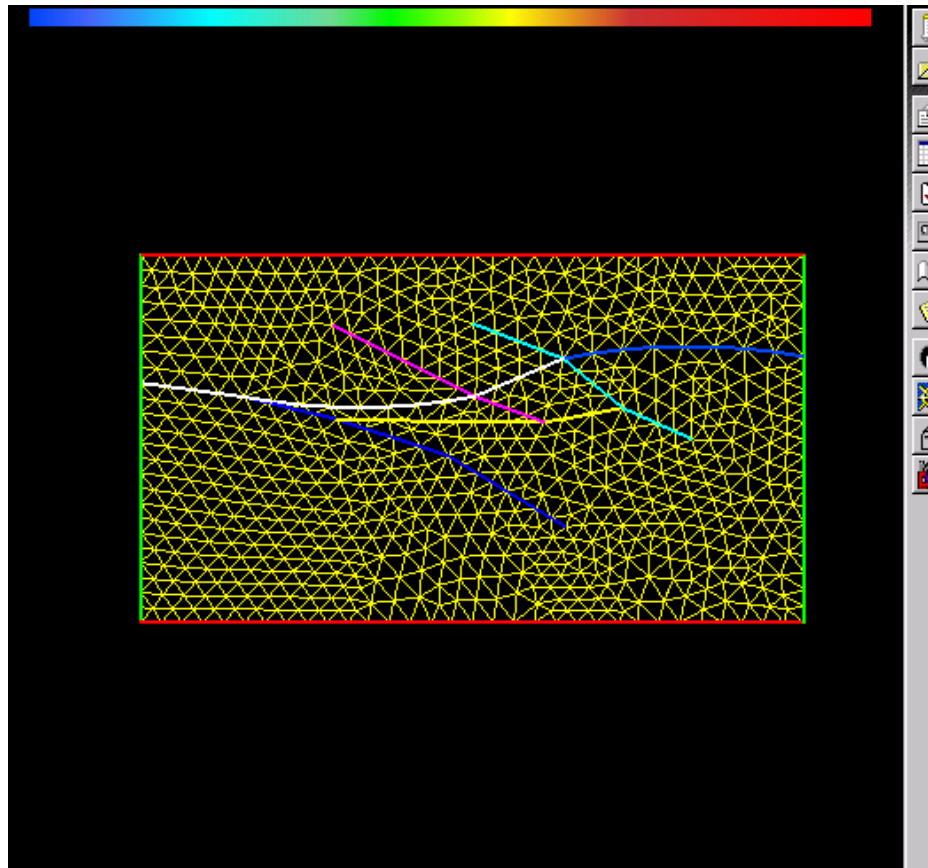


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Regionally varying properties

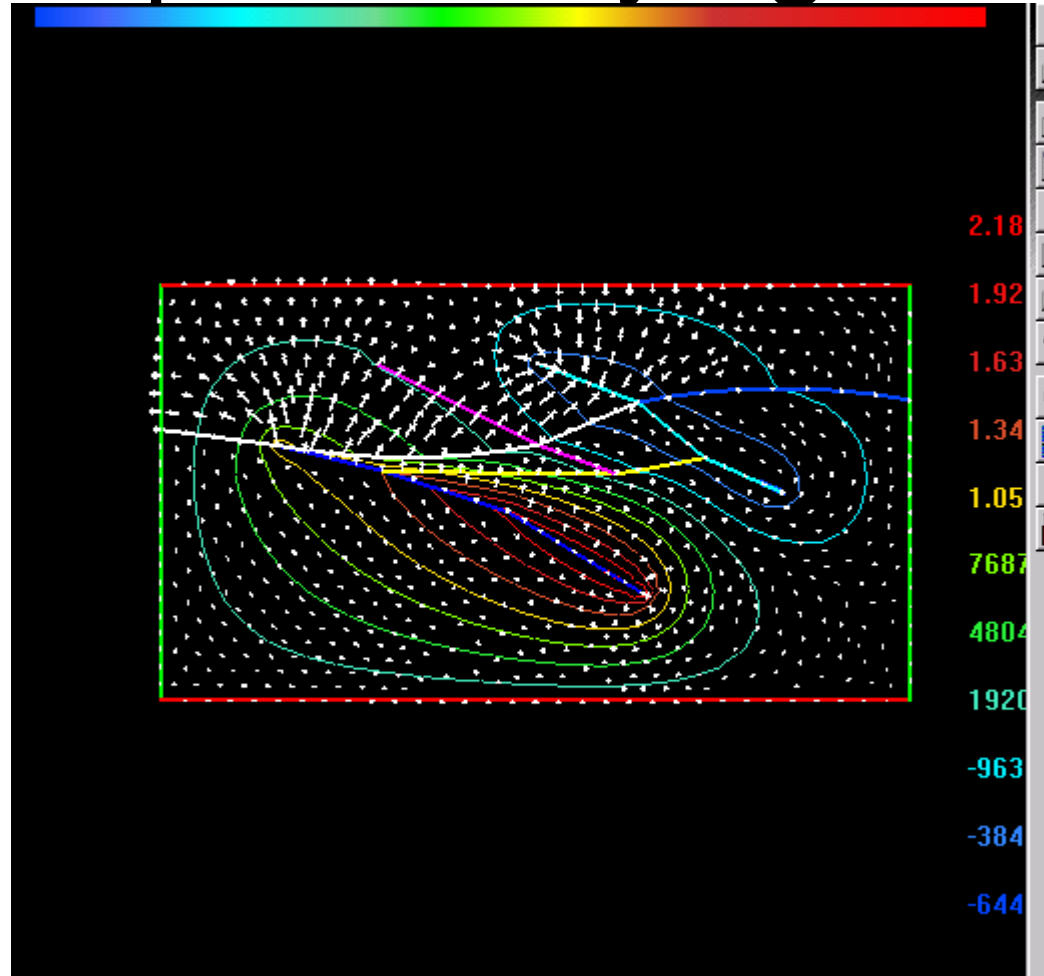
- In this model, the upper region is taken to be basalt, and the lower region dolerite, of lower permeability. The extra dividing paths are shown in the next mesh plot

Regionally varying properties



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Fluid Flow and mass transport - varying rock

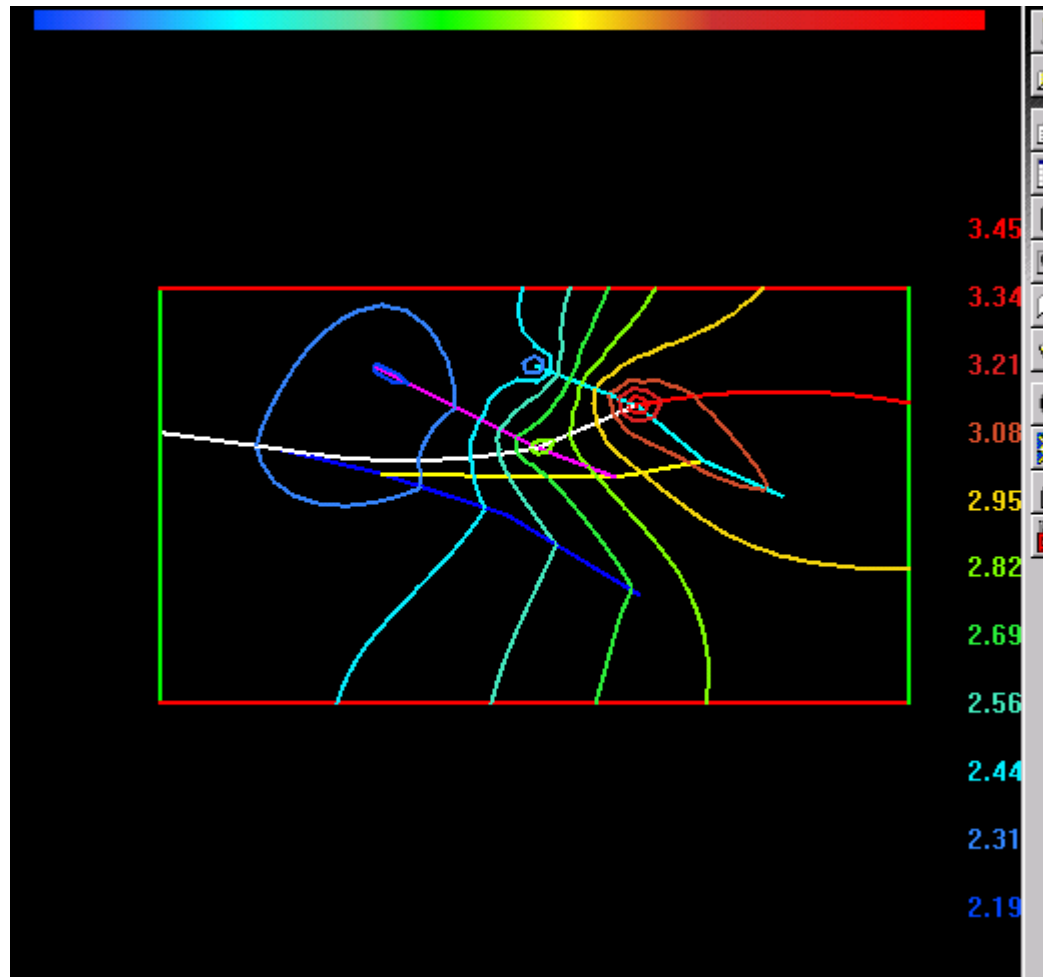


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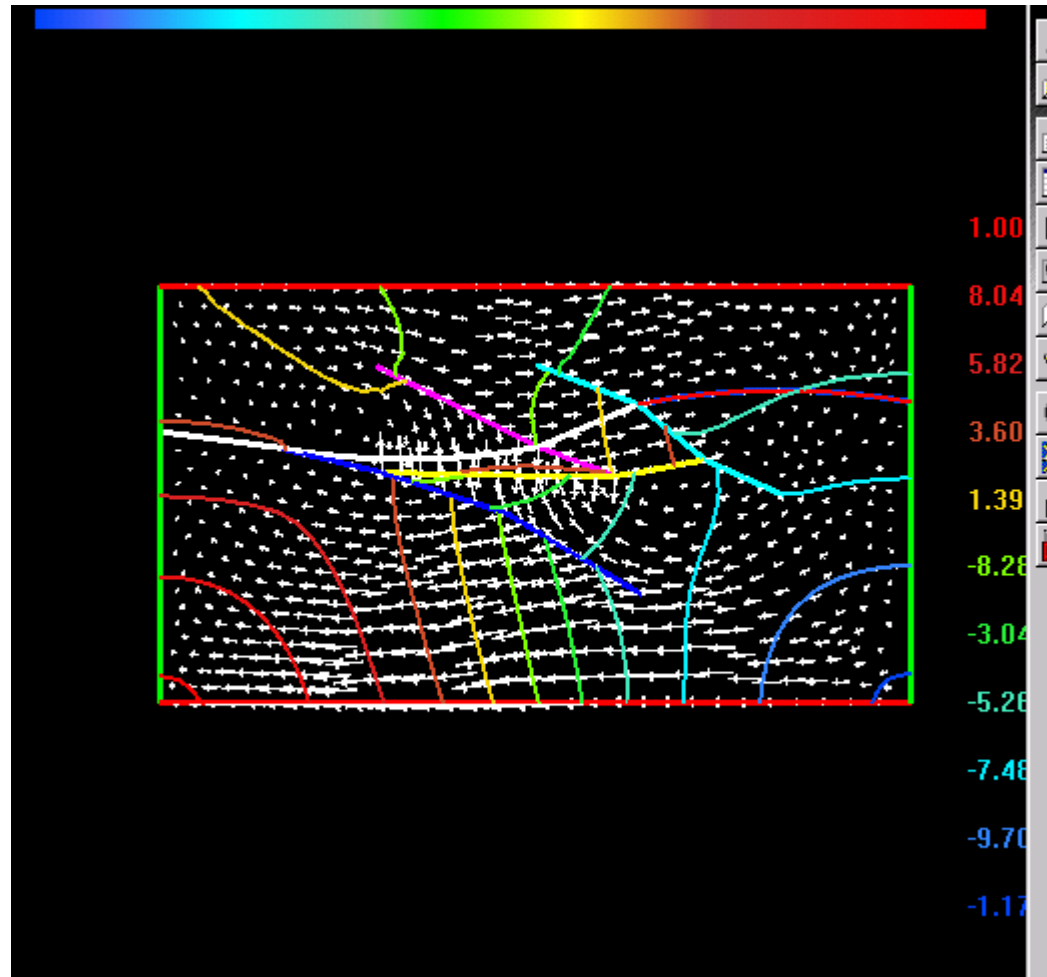
Chemical species transport - varying rock

- In the next slide, note now that local maxima of concentration appear near the transition of rock properties

Fluid Flow and mass transport - varying rock



Stress-strain displacement - varying rock



Stress-strain displacement - varying rock (detail)

