Numerical investigation of fault activation mode and formation of oriented-orebodies: application to the uranium deposits of the Athabasca Basin, northern Canada

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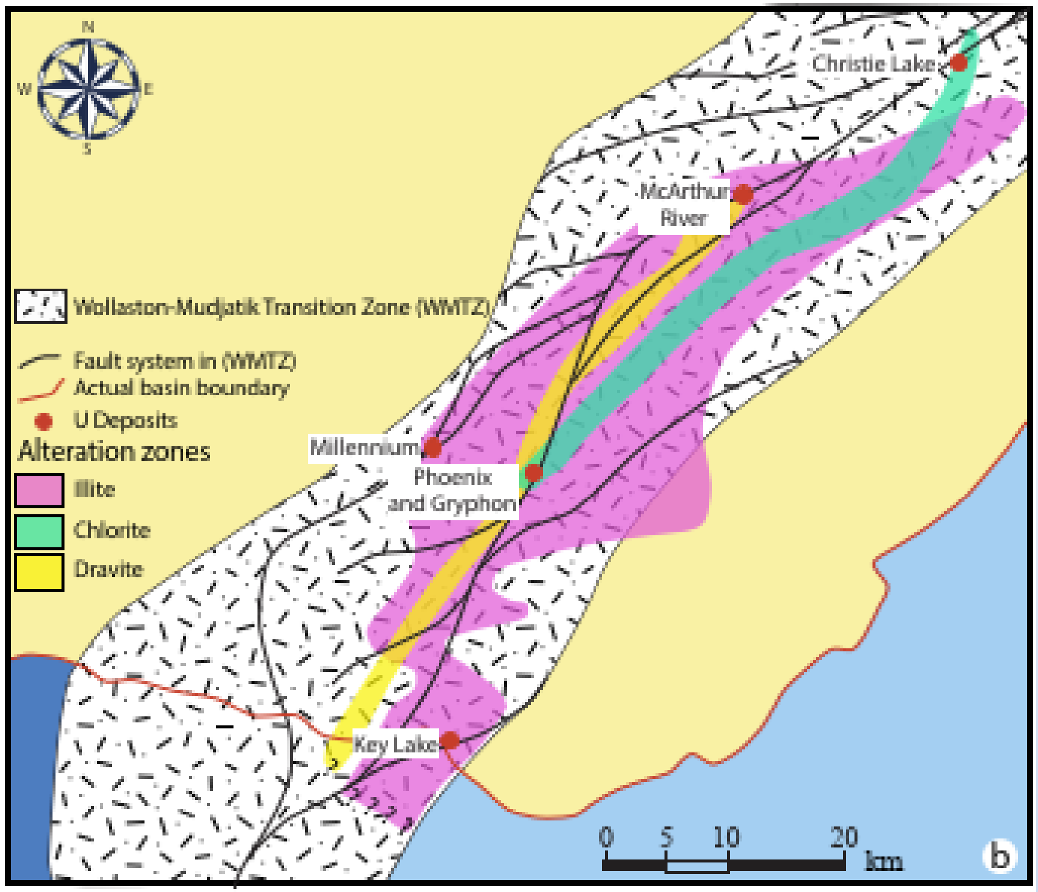
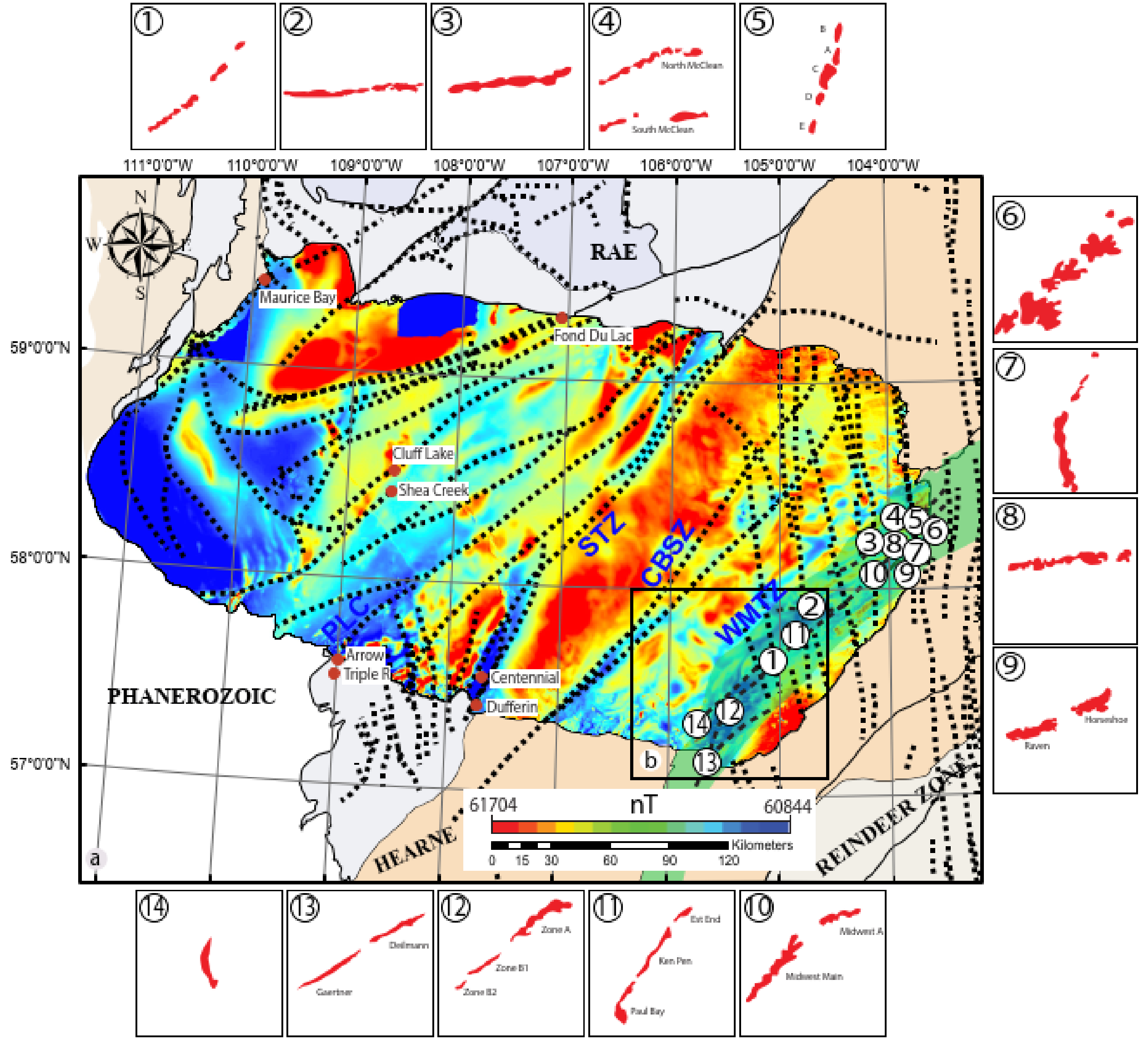
Unconformity-related Uranium Deposits, Athabasca Basin as prototype



Eldursi et al. under review JSG, modified after Jefferson et al. 2007



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Main concern:

1. At deposit-scale, how faults that are associated to URU are activated? mechanically (tectonic convergence), or hydraulically, due to triggering of over-pressured fluid?

2. What is the link between regional, and deep-seated faults and local and superficial fault system observed at mineralization sites?

1) In the first modeling type (simplified 3-D models of two intersecting faults)

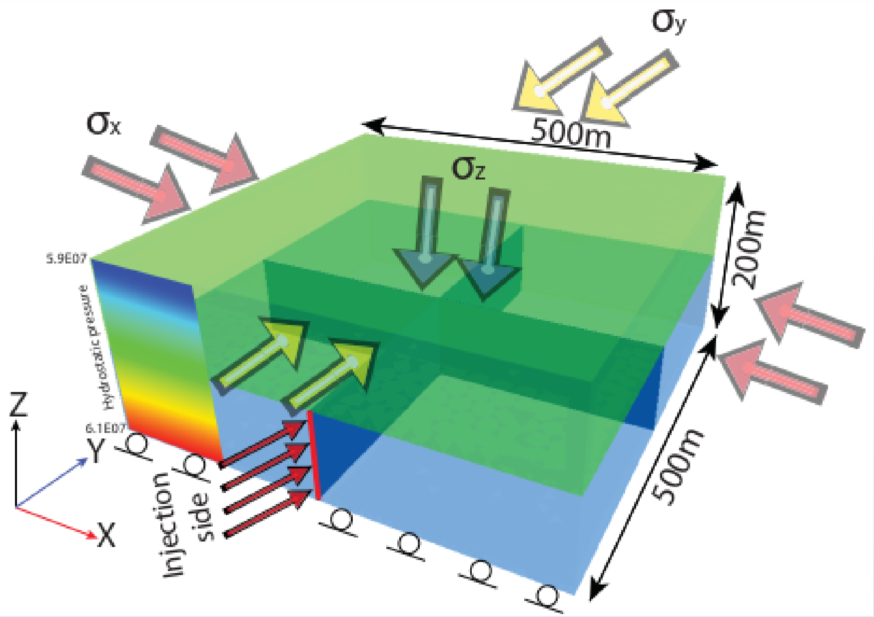
Evaluate faults' responses to hydromechanical process at intersection zone due to fluid circulation. Examine different parameters through 3D simplified models:

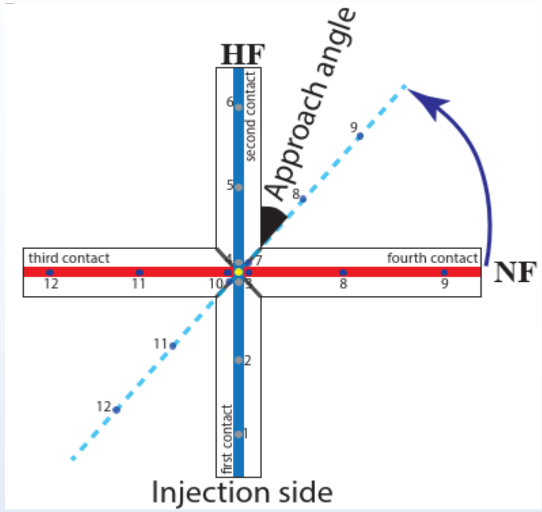
1. The effect of approach angle
2. The effect of basin permeability
3. The effect of burial depths
4. The effect of fluid pressure

2) In the second modeling type (complex 3-D model of the Cigar Lake deposit (Phase 2)

The purpose is to determine the mechanism (tectonic convergence versus hydraulic activation) capable to activate the E-W fault in the Cigar Lake area.

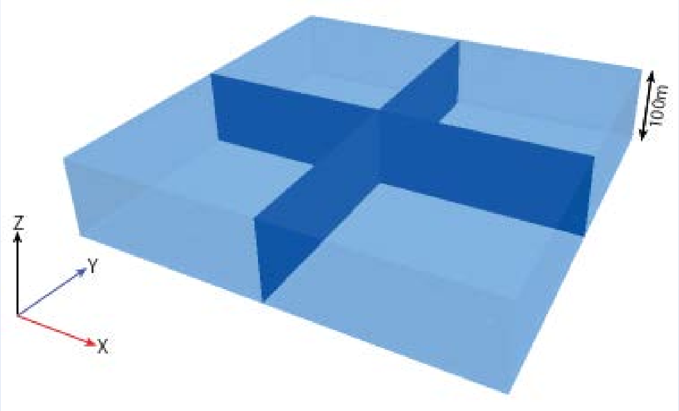
Numerical protocol and model setup





Observation points are assigned along the hydraulic and natural fracture to record the stresses and displacements along the two fractures

	Basin	Basement
Rock density	2550	2600
Permeability (m^2)	1E-12	1E-18
porosity	0.1	0.01
Bulk modulus (Pa)	3.2E10	4.95E10
Shear modulus (Pa)	4.0E9	2.9E10
Fault properties		
Normal stiffness (Pa/m)	4.8E9	
Shear stiffness (Pa/m)	2E8	
Initial hydraulic aperture (m)	0.5E-4	
Maximum hydraulic aperture (m)	1E-3	
Residual hydraulic aperture (m)	1.0E-5	
Friction angle	30	
Dilation angle	5	
Tensile strength (Pa)	6.0E5	
Cohesion (Pa)	1.0E4	
Unconformity properties		
Normal stiffness (Pa/m)	1E10	
Shear stiffness (Pa/m)	1E10	
Initial hydraulic aperture (m)	0.5E-5	
Maximum hydraulic aperture (m)	0.5E-5	
Residual hydraulic aperture (m)	0.5E-5	
Tensile strength (Pa)	1E30	
Cohesion (Pa)	1E30	



	Normal Regime	Reverse Regime	Strike-slip Regime
$\sigma_z=\sigma_v$	120MPa	120MPa	120MPa
$\sigma_x=\sigma_h$	84MPa	125MPa	108MPa
$\sigma_y=\sigma_H$	84MPa	156MPa	144MPa

The numerical protocol includes three stages:

1. Mechanical equilibrium
2. Hydrostatic equilibrium
3. Fluid injection

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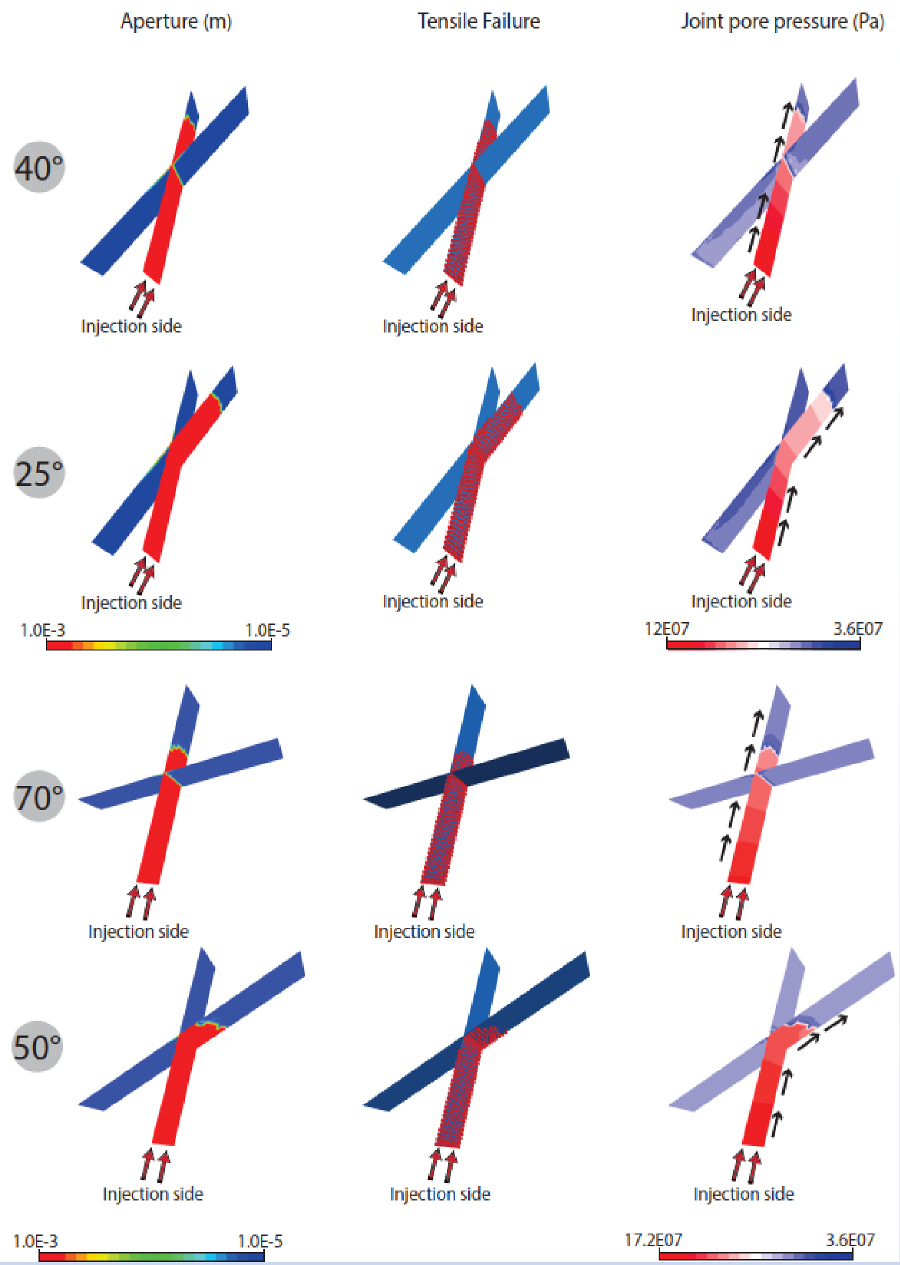
Normal Regime

Approach Angle	Fluid flow
90°	crosses
70°	crosses
50°	crosses
30°	crosses
10°	diverts

Reverse and Strike-slip faulting regimes

Approach Angle	Fluid flow
90°	crosses
70°	crosses
50°	diverts
30°	diverts
10°	diverts



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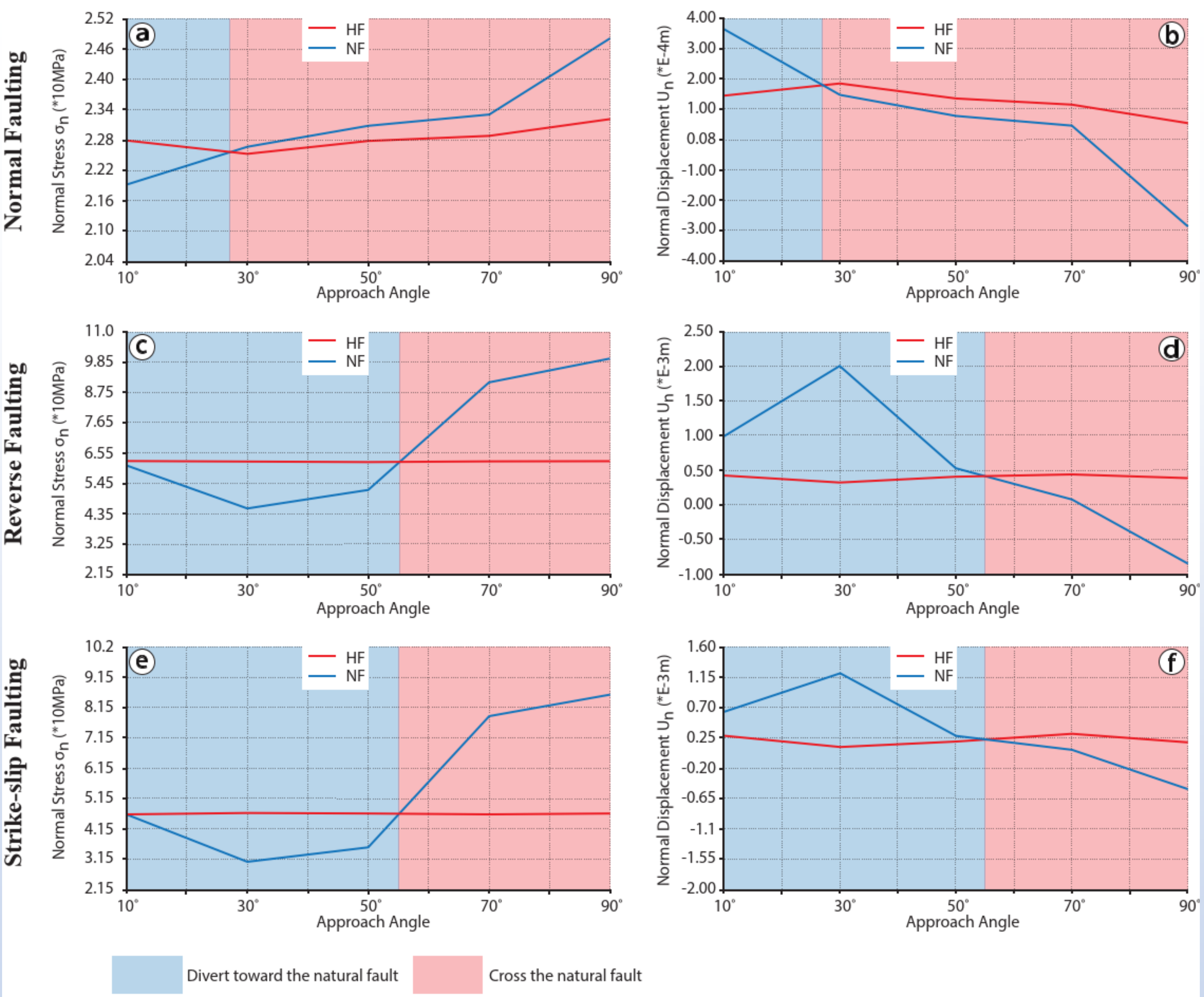

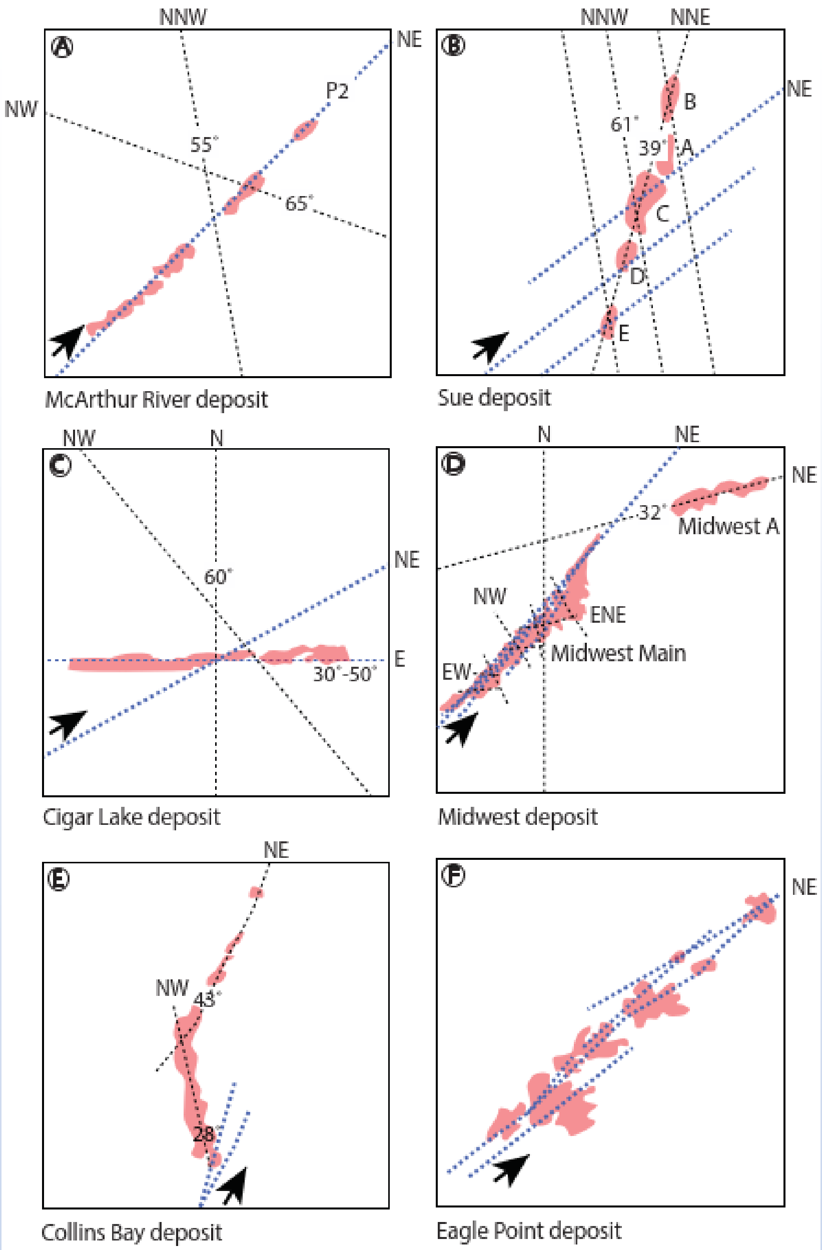

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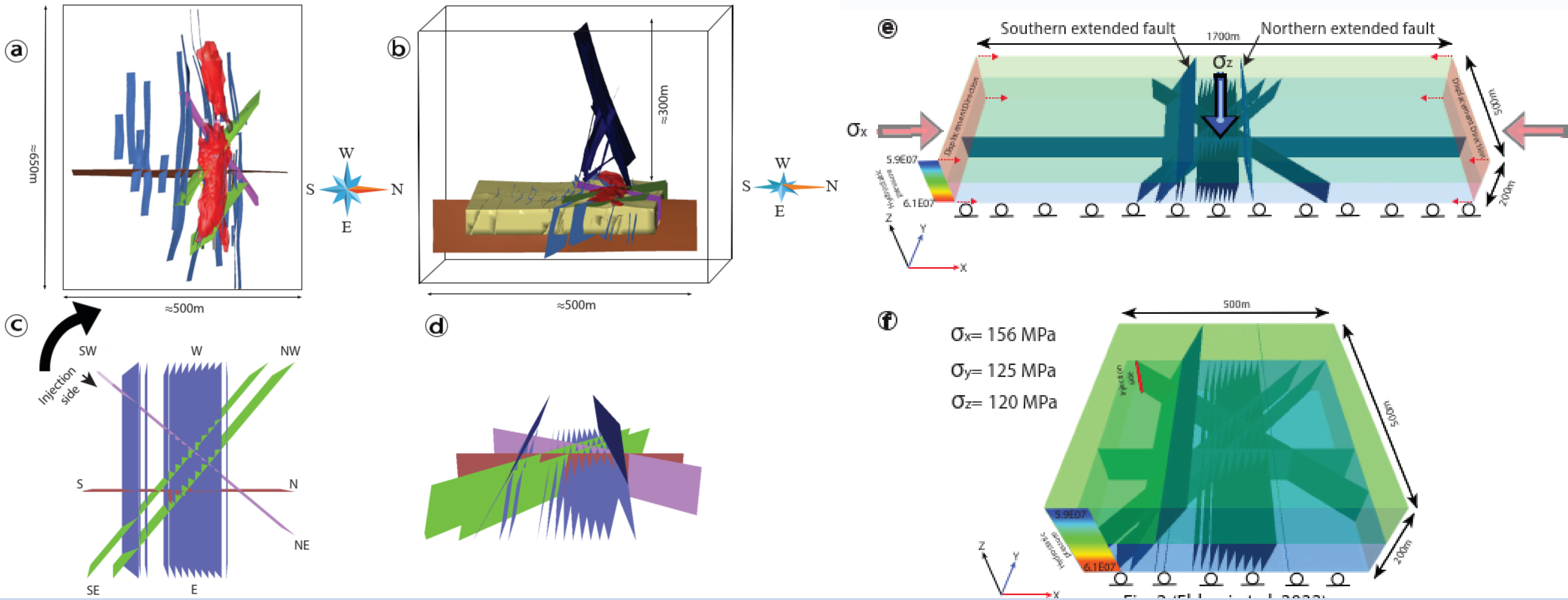
Series of 3D complex model (Cigar Lake area)

GoCAD model of the Cigar Lake (Phase 2)



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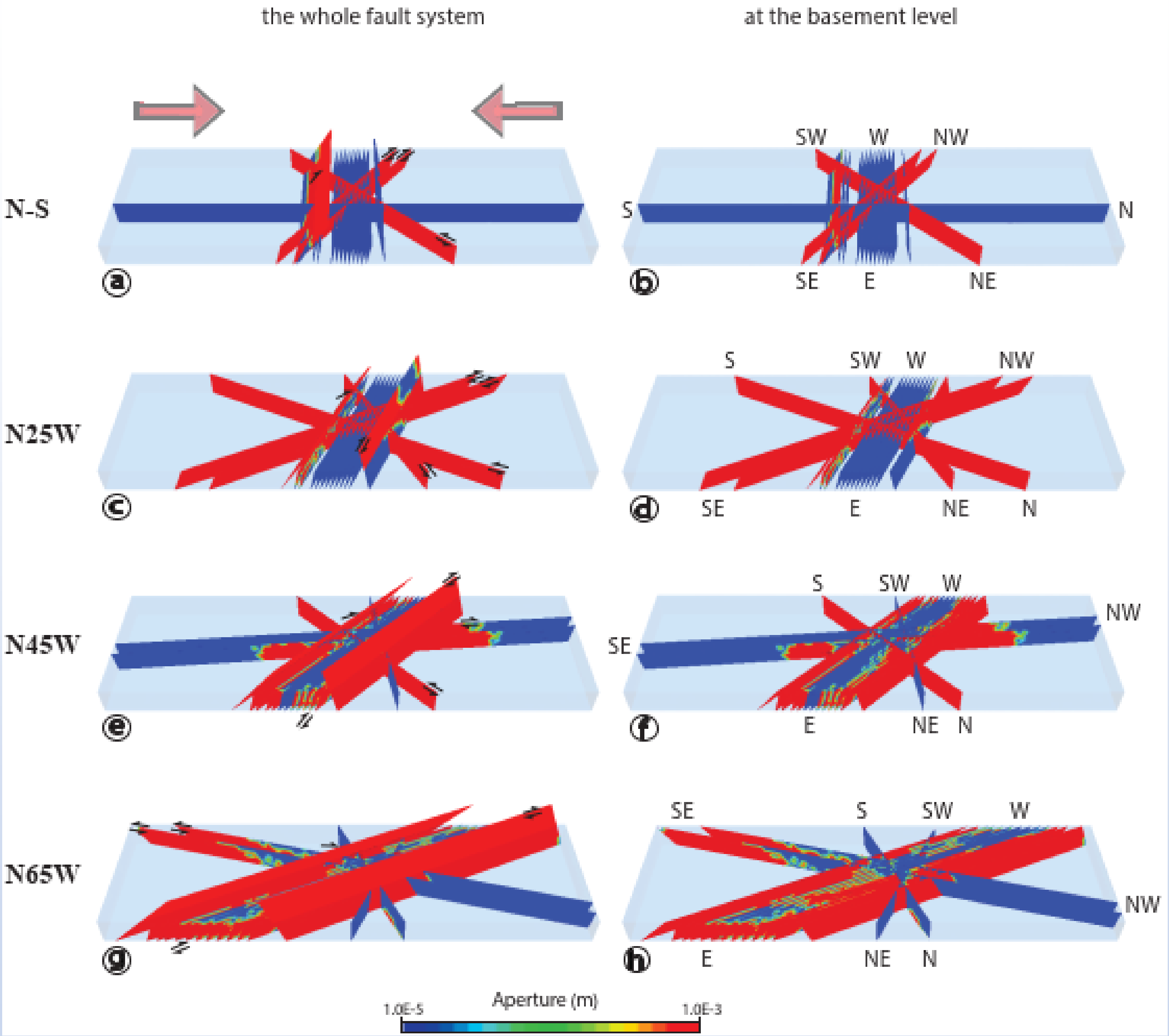
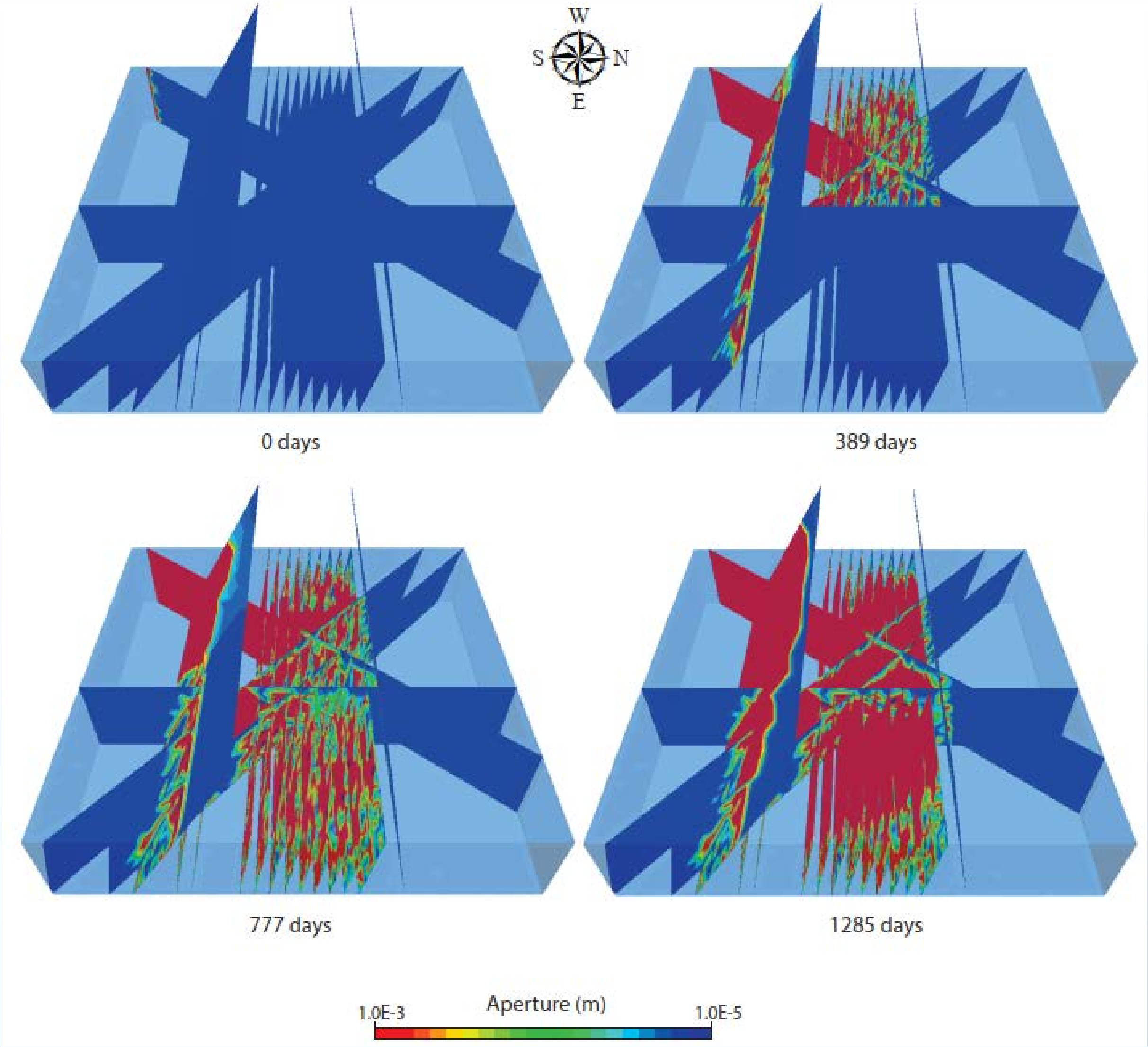
Horizontal convergence



Hydraulic activation



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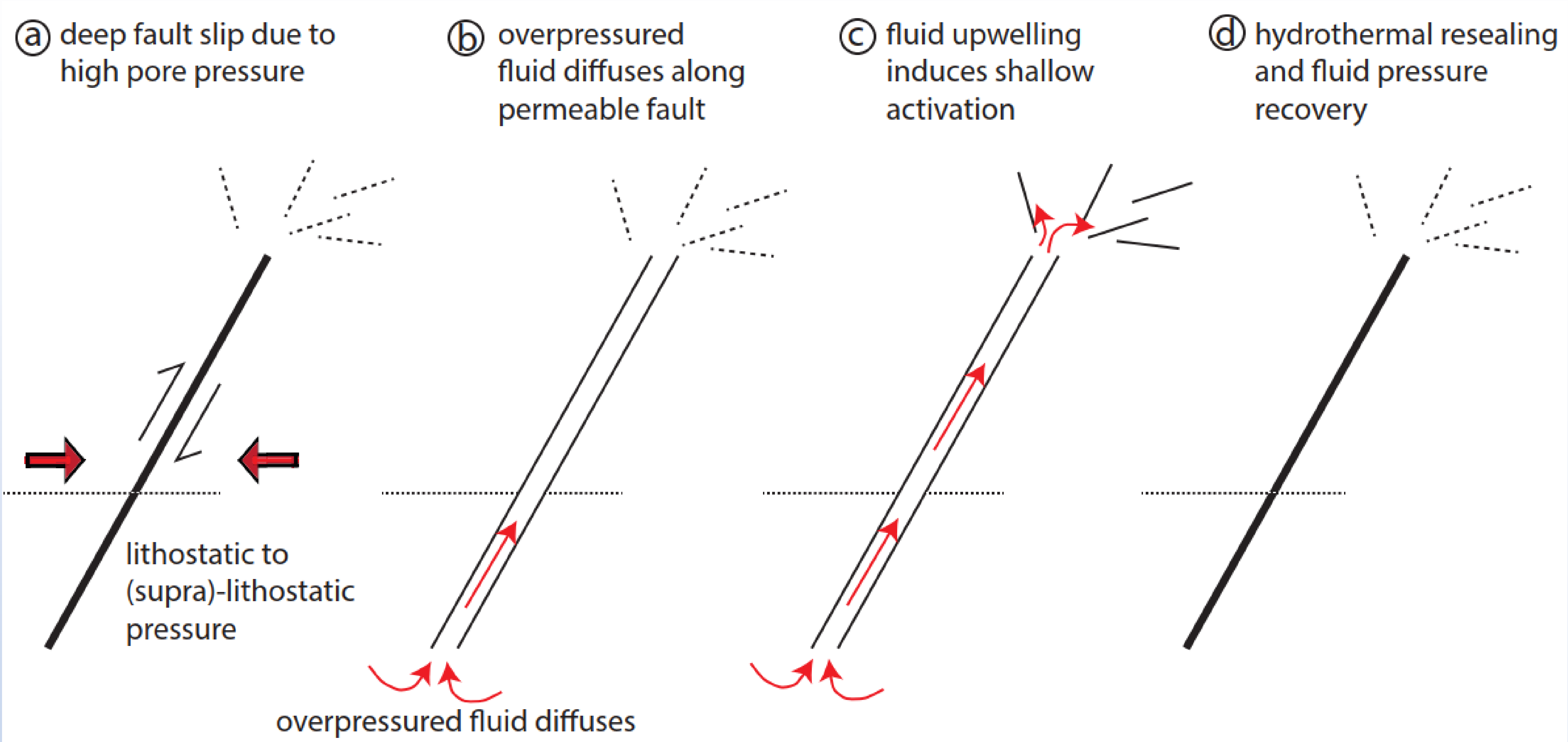
Potential Reactivation Mechanism



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