Hydraulic Fracturing and Reservoir Geomechanics in Unconventional reservoirs

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Reservoir Geomechanics

Develop an efficiently coupled fluid flow and rock deformation model to characterize stress change in reservoirs with **complex fracture geometry**

Part 1: Coupled geomechanics and fluid flow model

In-house custom solver based on sequentially implicit method (Fixed stress split)

- Fluid flow equation

$$\left(\frac{1}{M}+\frac{b^2}{K_{dr}}\right)\frac{\partial p}{\partial t}+\frac{b}{K_{dr}}\frac{\partial \sigma_v}{\partial t}-\nabla\cdot\frac{k}{\mu_f}(\nabla p)=q$$

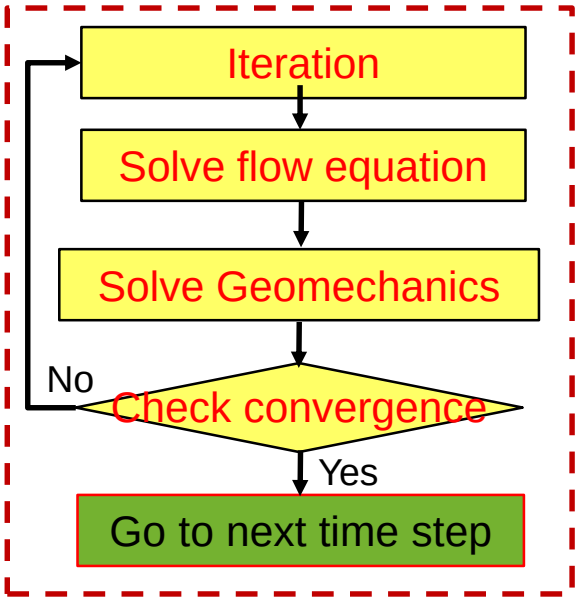
- Geomechanics equation

  Momentum balance $\nabla\cdot\sigma+\rho_b g=0$

  Stress-strain $(\sigma_v-\sigma_{v,0})+b(p-p_0)=K_{dr}\varepsilon_v$

  Substitute stress-strain in momentum balance

$$\nabla\cdot[\mu\nabla u+\mu\nabla u^T+\lambda Itr(\nabla u)]+\nabla\cdot\sigma_0-b\nabla p+b\nabla p_0=0$$

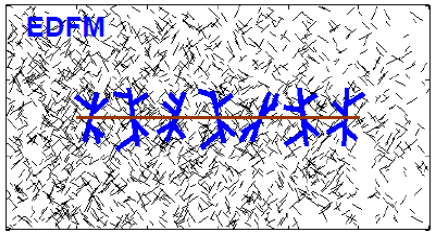


Reservoir Geomechanics

Part 2: Implementation of Embedded Discrete Fracture Model (EDFM)

The goal is to efficiently model complex fracture geometries using structured grids

- Matrix and fracture are modelled separately
- The two domains communicate through flow transmissibility

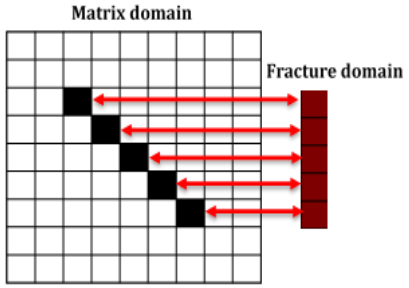


Moinfar et al., 2014

  - Mass conservation for matrix domain

Flow transmissibility

$$\left(\frac{1}{M}+\frac{b^2}{K_{dr}}\right)\frac{\partial p}{\partial t}+\frac{b}{K_{dr}}\frac{\partial \sigma_v}{\partial t}-\nabla\cdot\frac{k}{\mu_f}(\nabla p)=\sum_{i=1}^{n_{NNC}} T_{f-m,i}\left(p_{f,i}-p\right)$$

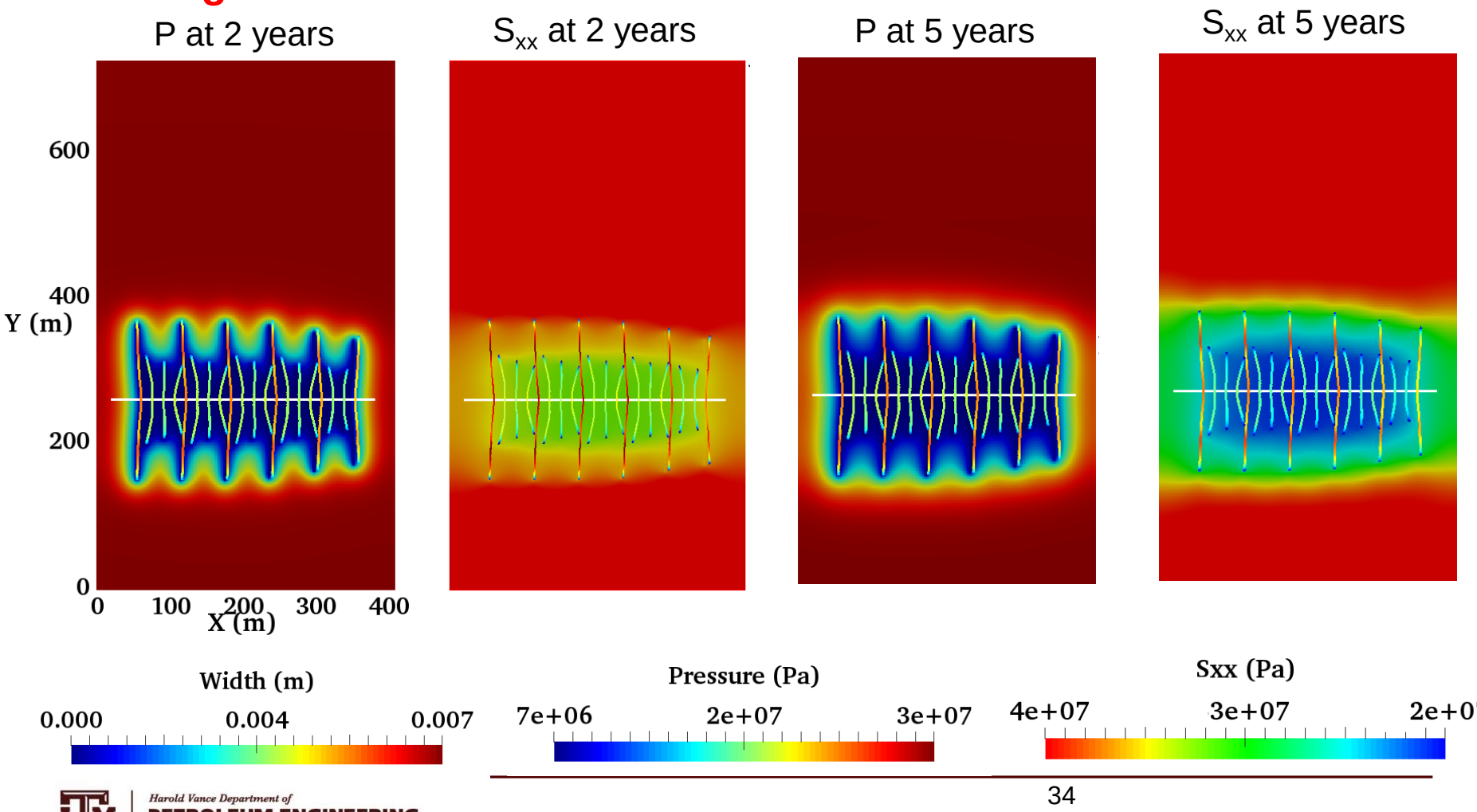


  - Mass conservation for fracture domain

$$\frac{1}{M_f}\frac{\partial p_f}{\partial t}-\nabla\cdot\frac{k_f}{\mu_f}(\nabla p_f)=q+\lambda_t T_{f-m}\left(p^n-{p_f}^n\right)$$

Effect of Parent Well Production

- Pressure distribution changes with time and locations
- Stress change is a function of **time and locations: both magnitude and orientation**



Heterogeneous Stress State

- Pressure distribution changes with time and locations
- Stress change is a function of **time and locations: both magnitude and orientation**

Orientation of S_{Hmax} without natural fractures

Orientation of S_{Hmax} with natural fractures