Coupled reservoir geomechanics and multiphase flow in fractured porous media.

HAWEZ, H., SANAEE, R. and FAISAL, N.H.

2020

Coupled Reservoir Geomechanics and Multiphase Flow in Fractured Porous Media

H. Hawez[1], R. Sanaee[2] and N. H. Faisal[3]

[1] *Robert Gordon University, Garthdee Road, Aberdeen, AB10 7GJ, UK, h.kukha-hawez@rgu.ac.uk*
[2] *Robert Gordon University, Garthdee Road, Aberdeen, AB10 7GJ, UK, sanaee1@rgu.ac.uk*
[3] *Robert Gordon University, Garthdee Road, Aberdeen, AB10 7GJ, UK, n.h.faisal@rgu.ac.uk*

Abstract

As a result of a rapid pressure reduction and lack of understanding of hydromechanical behaviour at the fracture matrix interface, a considerable amount of hydrocarbon reserves will remain in place in fractured reservoirs. Therefore, rigid numerical modelling of multiphase flow in geologically complex reservoirs is an essential issue for petroleum reservoir engineers.

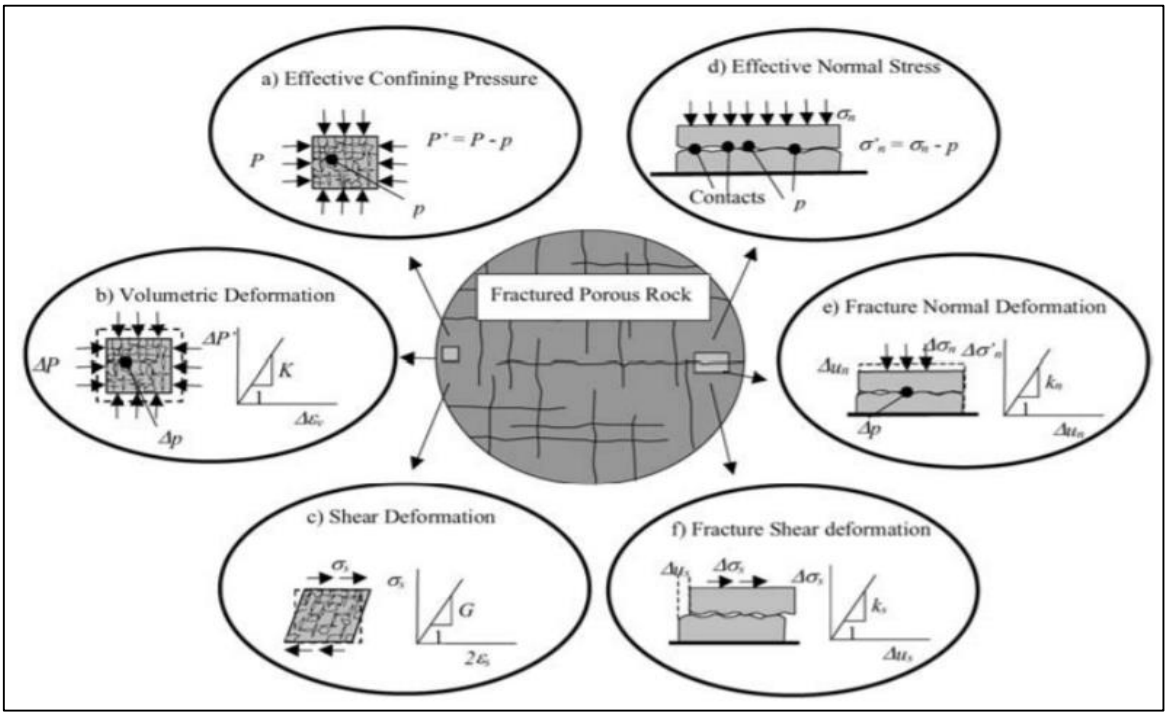


Figure 1: Illustrates the deformation of the porous matrix and macro fractures in fractured porous media[1].

$$\sigma = C\varepsilon + \alpha_B p_p I$$

References

1. Rutqvist J, Stephansson O. The role of hydrochemical coupling in fractured rock engineering. *Hydrogeol J*. 2003;11(1):7-40. doi:10.1007/s10040-002-0241-5

2. Biot MA. Mechanics of deformation and acoustic propagation in porous media. *J Appl Phys*. 1962;33(4):1482-1498. doi:10.1063/1.1728759

Coupled Reservoir Geomechanics and Multiphase Flow in Fractured Porous Media

ETP 9th Annual Conference
2-3 November 2020

Ph.D. Candidate: Haval Hawez, *School of Engineering, Robert Gordon University*

Principal Supervisor: Dr. Reza Sanaee, *School of Engineering, Robert Gordon University*

Co-Supervisor: Dr. Nadhimul Faisal, *School of Engineering, Robert Gordon University*

03.11.2020

Outline:

- Aims and Objectives
- Introduction
- Problem Statement
- Proposed Methodology
- Summary

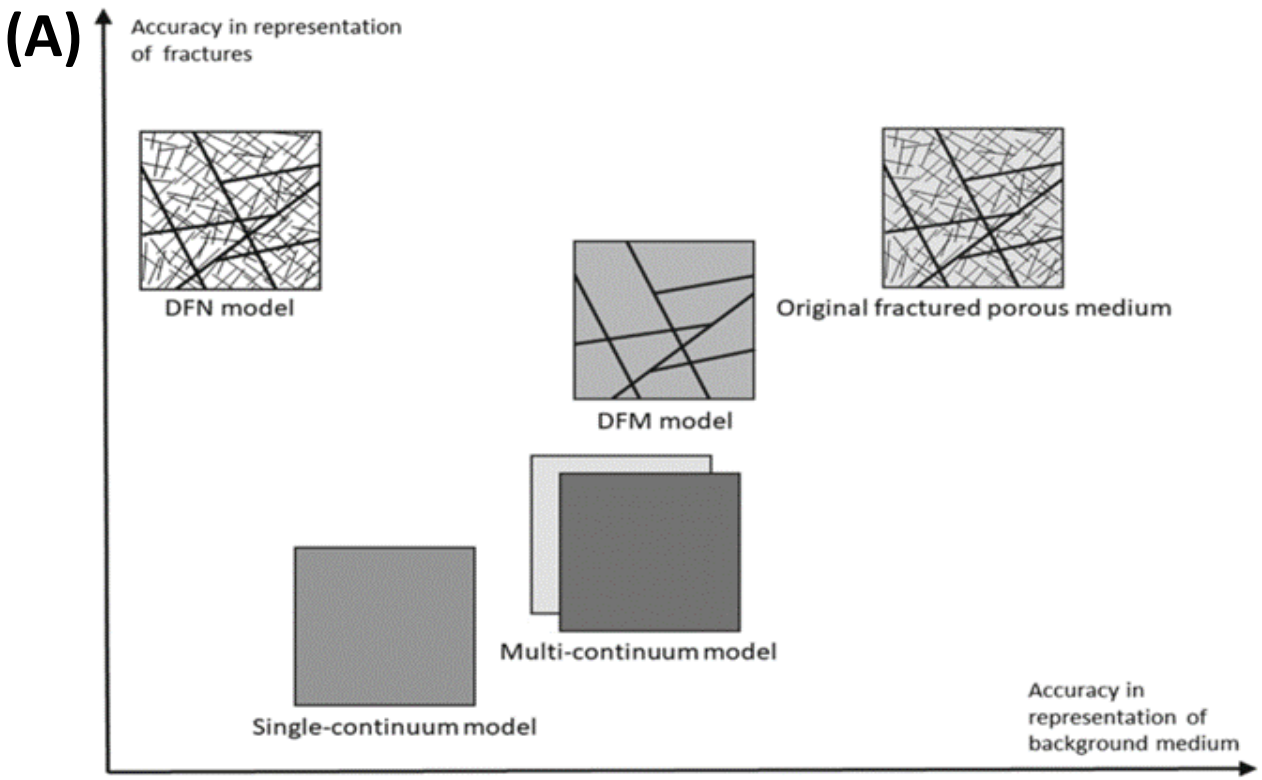
Objectives

- Review of distinct types of naturally fractured porous media modelling.
- The effect of effective stress and displacements on the petrophysical properties and fracture aperture change.
- The effect of effective stress on transient multiphase flow behavior at fracture matrix interface.

Introduction

- Multiphase fluid flow take place while production in the subsurface.
- The physical properties of the multiphase flow is governed by conservation of mass, momentum and energy.
- Geomechanics is the theoretical and applied science of the mechanical behavior of geological material.
- The role of geomechanics is to predict when failure would occur, assess its risks and opportunities and recommend mitigation plans.

Introduction



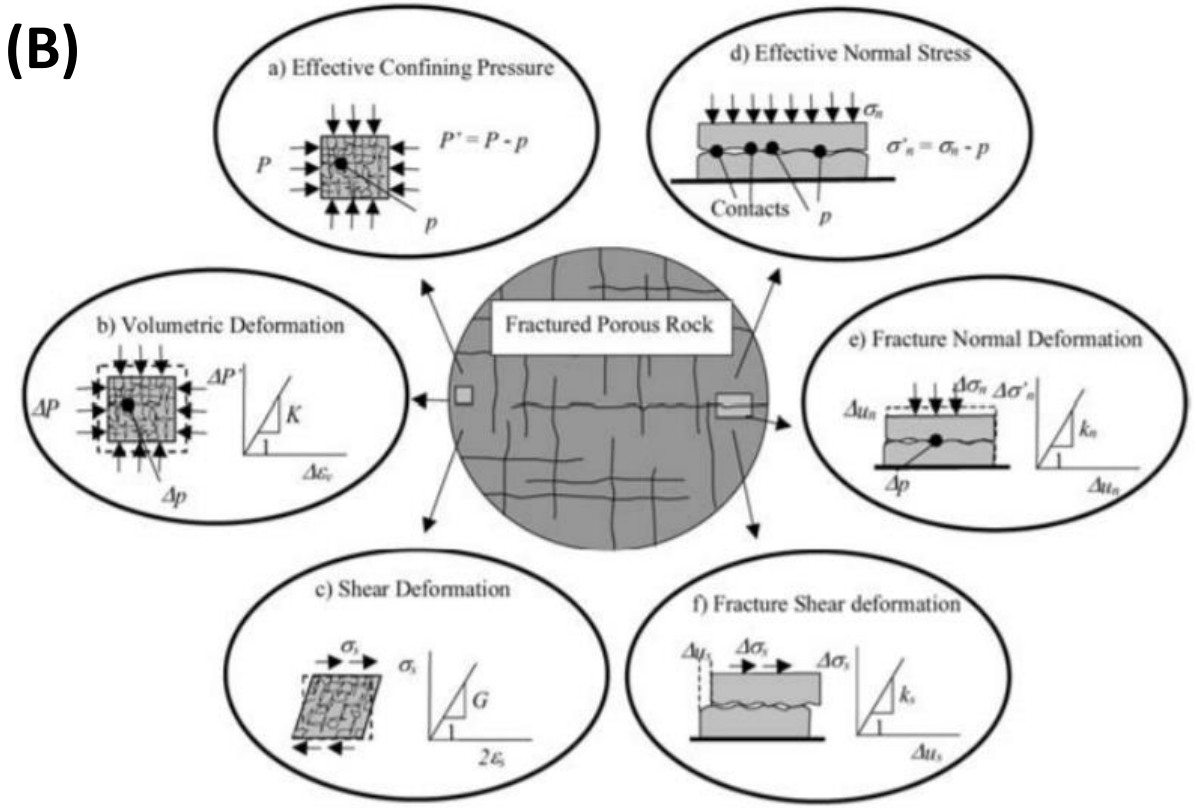


Figure: Illustrating **(A)** the fractured porous media model concepts **(B)** the deformation of the porous matrix and macro fractures in fractured porous media.

.

Problem Statement

The lack of understanding the fracture-matrix hydro-mechanical interaction that causes a rapid decline in the initial production rate and unfavorable recovery factor.

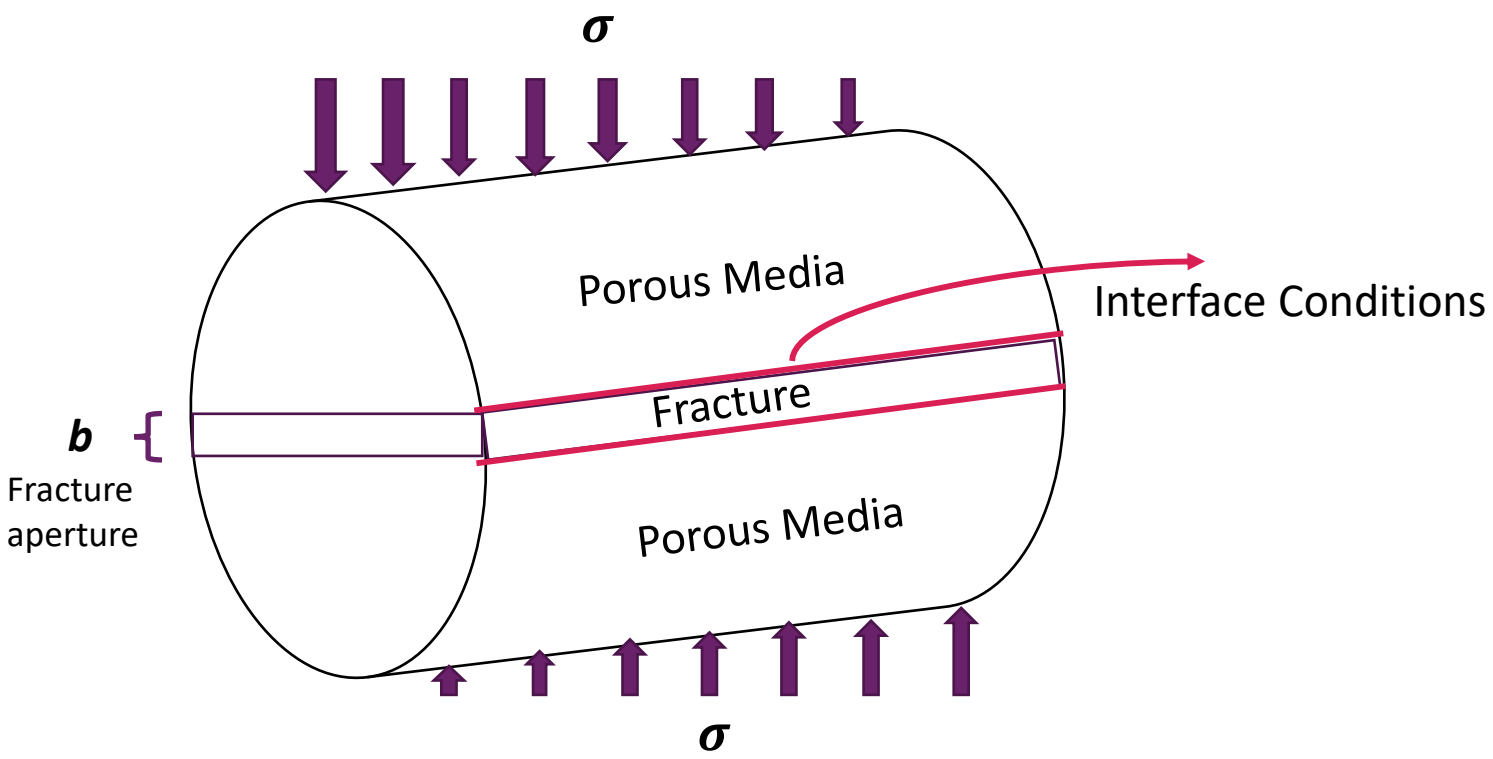


Figure: Shows a 3D fractured core model

$$\boldsymbol{\sigma = C\varepsilon + \alpha_B p_p I}$$

$where$:
$\sigma = cauchy\ stress\ tensor$
$C = drained\ elasticity\ of\ matrix$
$\varepsilon = strain\ tensor$
$\alpha_B = Biot\text{-}Willis\ Coefficient$
$p_p = pore\ pressure$

Methodology

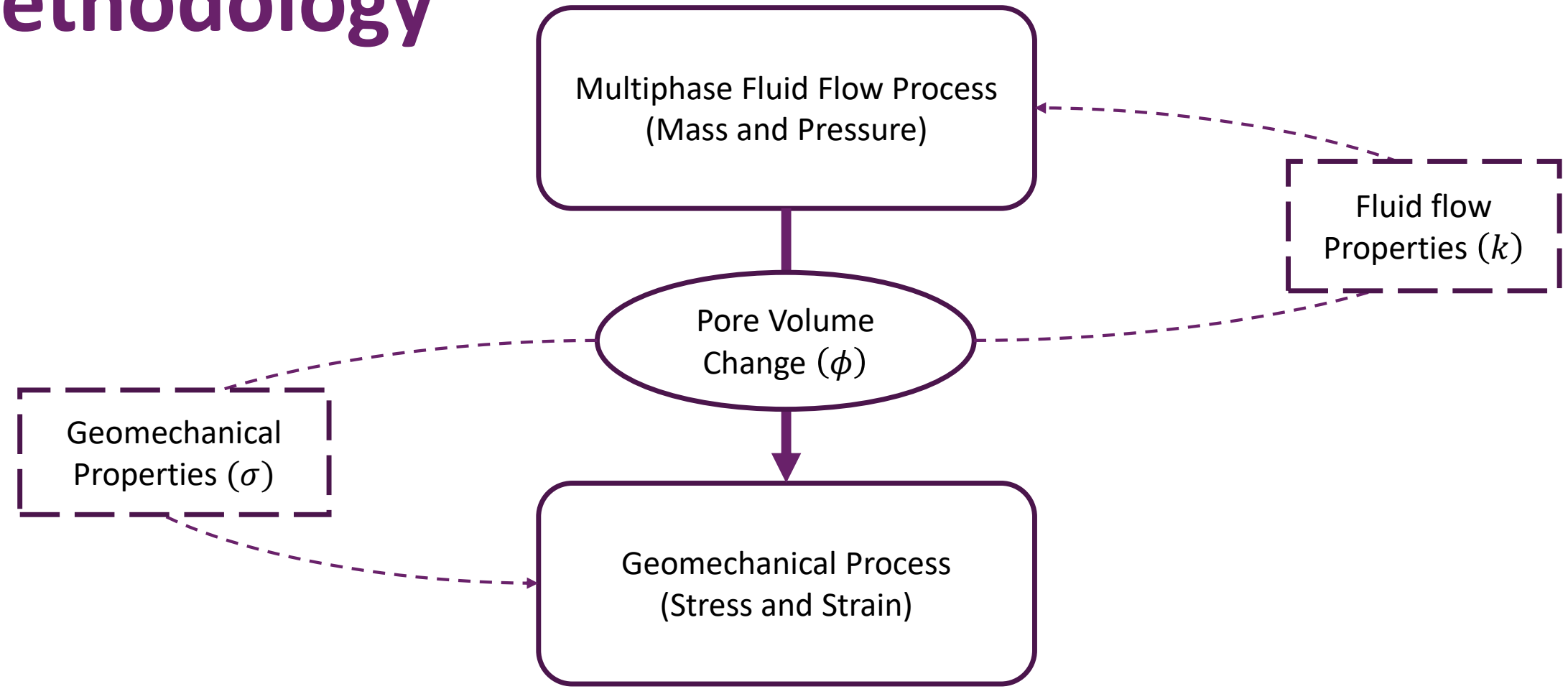


Figure: Schematic Coupling of Geomechanics and Multiphase Flow.

Methodology

1. Mathematical Formulation
2. Numerical Modelling
3. Numerical Experiment

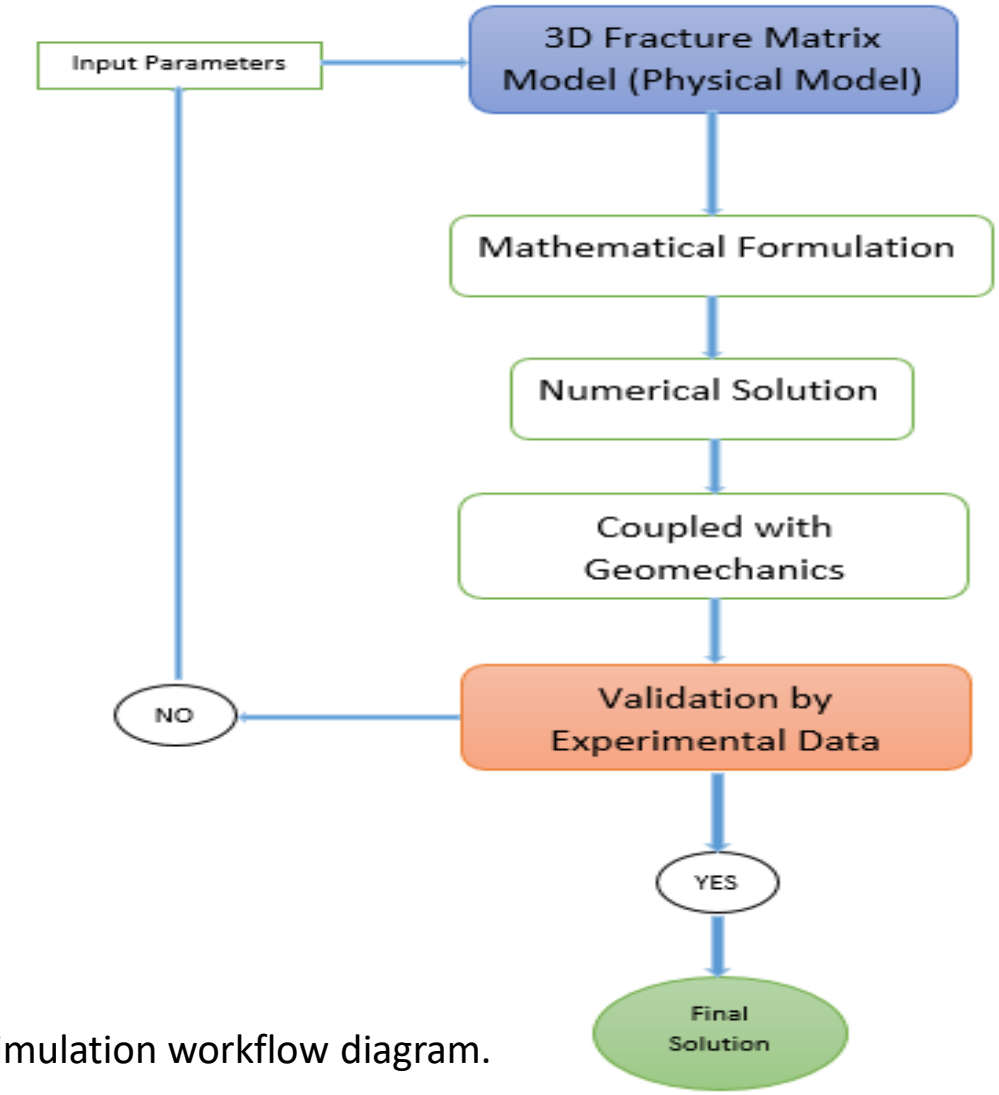


Figure: Shows the simulation workflow diagram.

Simulation Progress

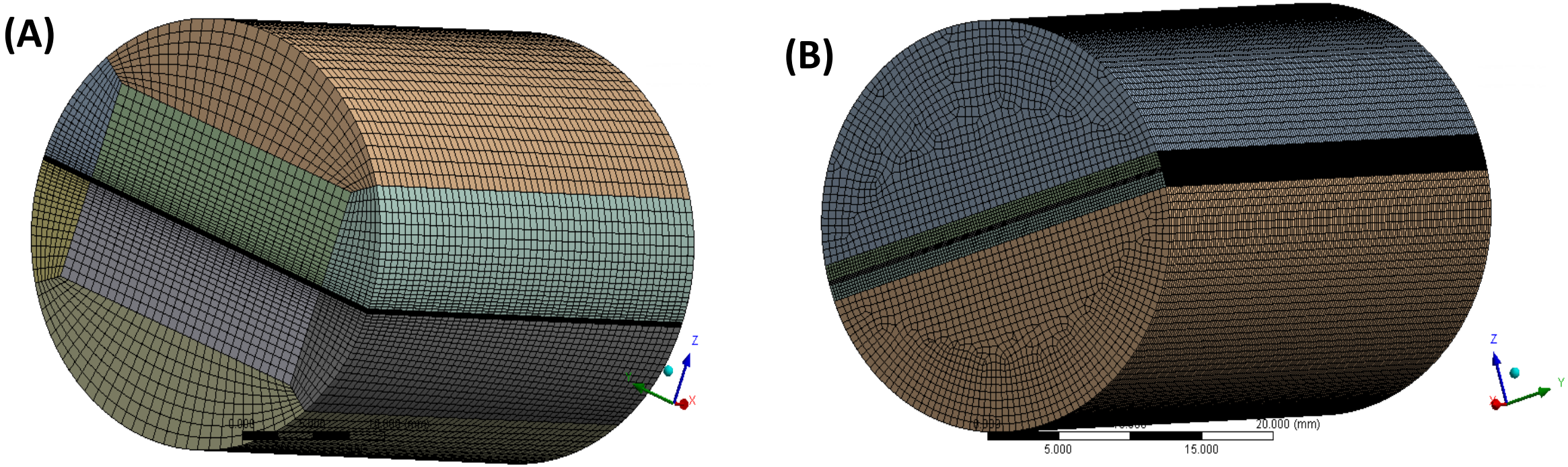
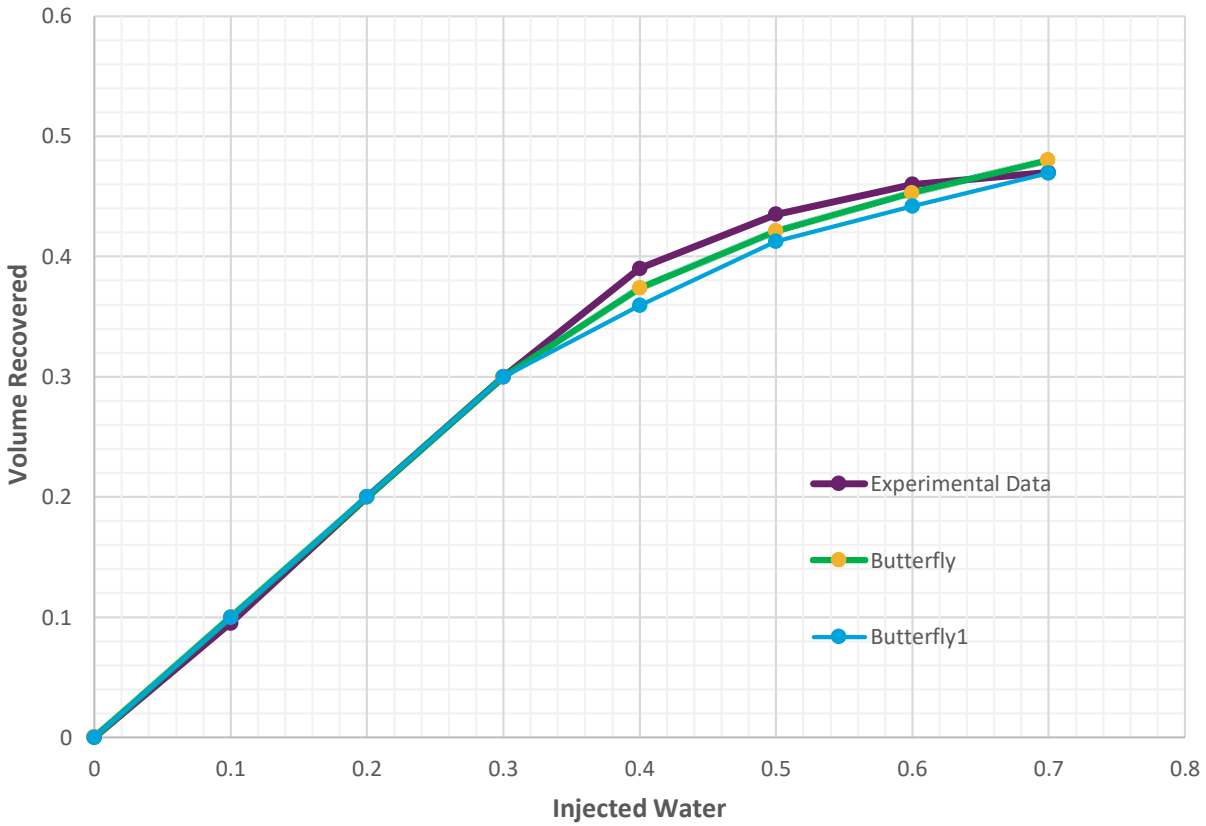


Figure: Shows (A) the Butterfly structured meshing (B) the Semi O-ring meshing.

Simulation Progress

(A)



(B)

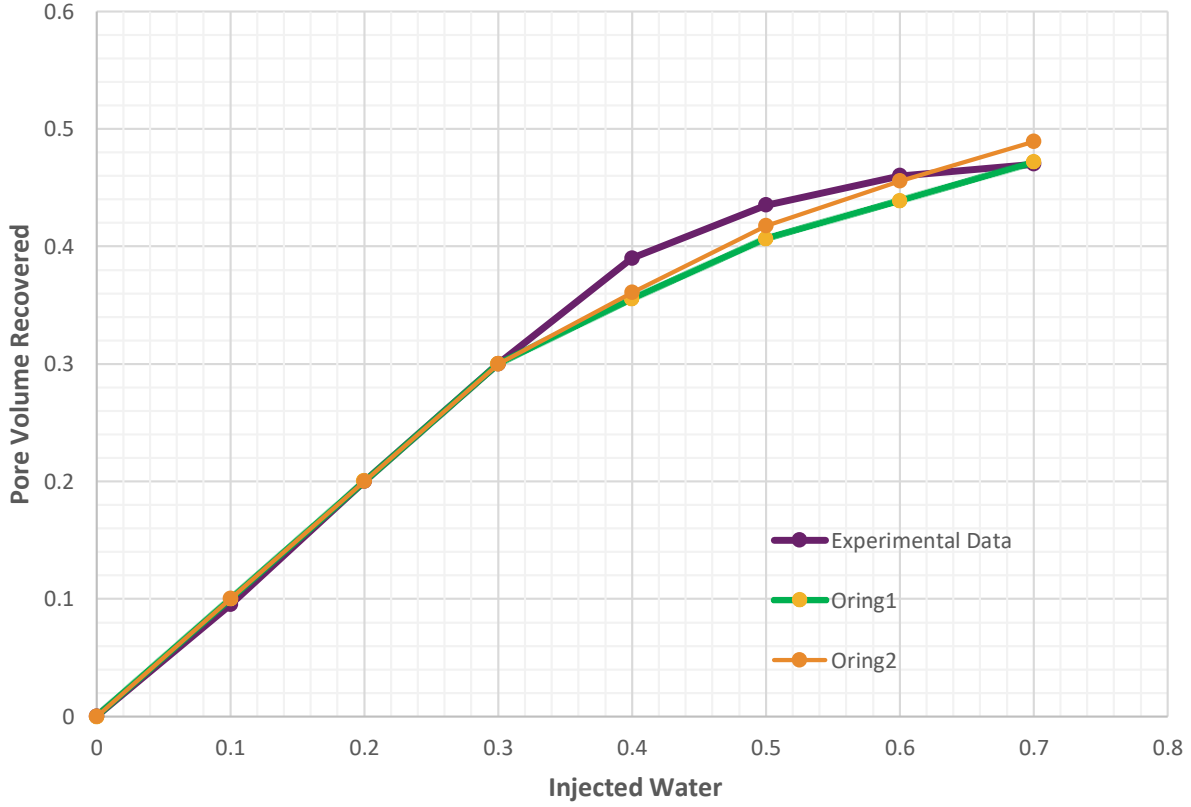


Figure: Shows the result of experimental data with **(A)** the Butterfly structured meshing **(B)** the Semi O-ring meshing.

Summary

- Modelling of naturally fractured reservoirs are still a challenging issues.
- The multiphase flow behavior should be explored at fracture matrix interface to reduce GOR and water cut.
- The coupled geomechanics and fluid flow are recommended for fractured and tight rock reservoirs.

References

Biot MA. Mechanics of deformation and acoustic propagation in porous media. *J Appl Phys*. 1962;33(4):1482-1498. doi:10.1063/1.1728759

Evren Unsal, S. K. (2009). Simulation of multiphase flow in fractured reservoirs. *Springer Science + Business Media B.V.* , 527–538.

Hossam I., P. A.-K.-H. (2012). Modeling and Validation of Fluid Flow-Geomechanics of Mauddud Reservoir in Sabriya Field*. *AAPG International Convention and Exhibition.* Singapore: AAPG.

Rutqvist J, Stephansson O. The role of hydrochemical coupling in fractured rock engineering. *Hydrogeol J*. 2003;11(1):7-40. doi:10.1007/s10040-002-0241-5.

Sanaee R., G. F. (2012). Fracture-Matrix Flow Partitioning and Cross Flow: Numerical Modeling of Laboratory Fractured Core Flood. *COMSOL Conference.* Milan: Robert Gordon University.

Zhou Fangqi, S. A. (2014). An efficient finite difference model for multiphase flow in. *ScienceDirect*, 262-266.

Any Questions?