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FRACTURE MODELING IN OIL AND GAS RESERVOIRS USING IMAGE LOGS DATA AND PETREL SOFTWARE

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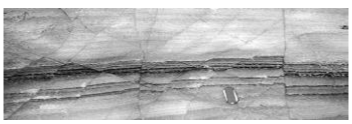
Graphical abstract



Abstract

The purpose of modelling the fractures is to create simulation properties with the power to predict the reservoir behaviour. Petrel software is one of the best softwares in the market that can do this task very well, but there is no available educational paper for every researcher. Therefore, in this work, a fracture modelling job was done in one of the most important Iranian fields using Petrel software and image log data. The purpose of this work was to determine the new information of the fractures in Gachsaran field and also to prepare a valuable educational paper for other researchers who are interested to learn about the fracture modelling. This work revealed that in this field, the longitudinal fractures had been parallel to minimum stress (Zagros trend), fracture intensity was the nearest to the major fault and northern flank, fracture porosity was 0-7%, fracture permeability was 0-6000 MD, and more valuable information is provided in this paper.

Keywords: Fracture modelling;Petrel software;Image log technology;Gachsaran field.

Abstrak

Tujuan model fraktur adalah untuk mewujudkan ciri-ciri simulasi dengan kuasa untuk meramalkan tingkah laku takungan. Perisian Petrel adalah salah satu perisian yang terbaik di pasaran yang boleh melakukan tugas ini dengan baik, tetapi tidak ada kertas penyelidikan bagi setiap penyelidik . Oleh itu, dalam kajian ini, kerja pemodelan fraktur akan dilakukan dalam salah satu bidang Iran yang paling penting menggunakan perisian Petrel dan log data imej. Tujuan karya ini adalah mencari maklumat baru berkenaan fraktur dalam bidang Gachsaran dan juga menyediakan kertas maklumat yang penting bagi penyelidik lain yang berminat untuk belajar tentang pemodelan fraktur. Kerja ini mendapati bahawa dalam bidang ini, fraktur membujur adalah selari dengan tekanan minimum (trend Zagros), keamatan fraktur adalah yang paling dekat dengan kesalahan utama dan rusuk utara, fraktur keliangan adalah 0-7 %, fraktur kebolehtelapan adalah 0-6000 MD, dan maklumat yang berharga diberikan dalam kertas kerja ini

Kata kunci: Pemodelan fraktur; Petrel perisian; teknologi log Imej; bidang Gachsaran

1.0 INTRODUCTION

Fracture modeling is a multi-step process involving several disciplines within the reservoir characterization and simulation. The main idea is to build on geological concepts and gather data, such as interpretation of beds, faults, and fractures from image log data, use of field outcrop studies as analogs for conceptual models, seismic attributes used as fracture drivers, etc. The next step is to transfer these data into a description of fracture intensity, which can be populated into a 3D geological framework model. Depending on the analysis of the fracture data, multiple sets of fractures can be identified; these can be the result of different tectonic events, such as over-thrusts and extensional faults, conjugate fractures related to bending or flexure of geological layers, or simple joints related to difference in lithology (Figure 1) [1,2,3].

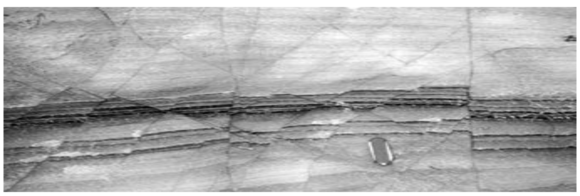


Figure 1 An example of fracture; field of view is about 3 ft [4]

Petrel is a Windows based software for 3D visualization, 3D mapping and 3D reservoir modeling, and simulation. The user interface is based on the Microsoft Windows standards on buttons, dialogs, and help systems. These make Petrel familiar to the majority of geoscientists today and ensure efficient usage of the application (Figure 2).

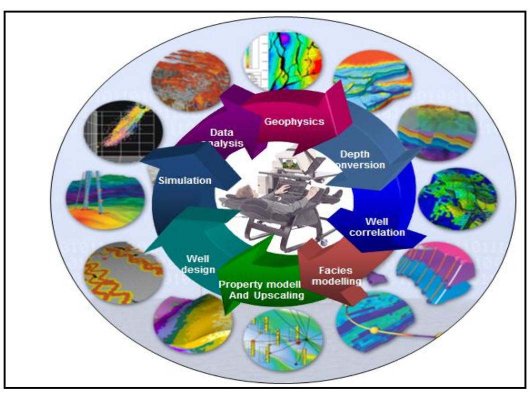


Figure 2 Petrel applications

Gachsaran field is located in the southwest of Iran (Figure 3) with an anticline structure. The thick sequence consists of anhydrite/salt, 80 km length, 300-1500 m thickness, 8-18 km width; provides an excellent seal and overlying Asmari, Pabdeh, Gurpi, and other reservoirs (Figure 4) [5].

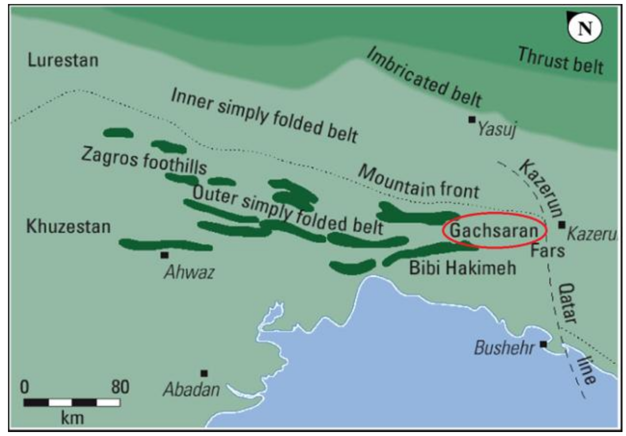


Figure 3 Location of the Gachsaran oil field [6]

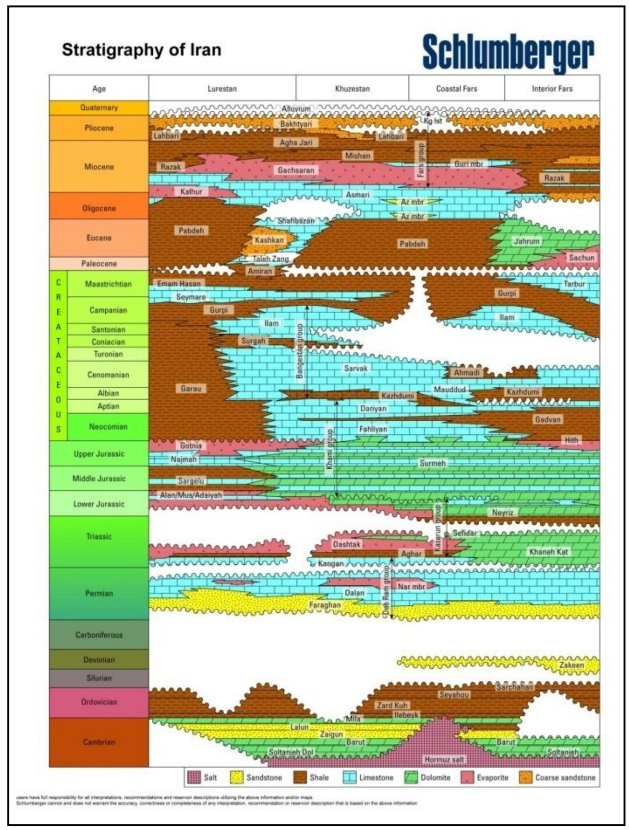


Figure 4 The location of Gachsaran oil field overlying the Asmari, Pabdeh, Gurpi, and other reservoirs, as well as stratigraphic nomenclature of rock units and age relationships in the Zagros basin [7]

In this work, a fracture modelling job was done in Gachsaran field using petrel software and image logs data in cooperation with other geological logs data in order to identify new information about the fracture system in this field and also to provide a valuable educational paper for other researchers.

2.0 MATERIALS AND METHOD

Once data had been identified, analyzed, and categorized, the fracture model was built. From our initial intensity description, we populated the fracture intensity in the 3D grid stochastically or deterministically. If we did it deterministically, we need to have a very good idea of where and how the fractures behave in the 3D grid; we can do this by using high confidence fault patches from the seismic volume attribute process called Ant-tracking, or an existing fault model. If no such data exists, users should use the stochastic method.

The ultimate goal was to identify 3D grid properties, which describe permeability and porosity for fractures, as well as the standard permeability and porosity we get from the matrix. Why do we need this? It is because many types of reservoirs are what we call dual porosity and possibly dual permeability reservoirs, and they are either naturally fractured (NFR), or consist of, for example, carbonates, which are vugular or heavily fractured due to tectonic processes. Some of these reservoir rocks are originally dense and have little flow or storage capacity in the matrix, but once fractured, certain areas will become high flow zones. To correctly model this in a simulator is, complex, and at best, quite inaccurate. Hence, users can try to resolve this problem by building a Discrete Fracture Network (DFN) model based on fracture intensity. Besides, upscaling properties based on a DFN model for Dual porosity simulation generates a second set of properties of permeability, porosity, and a sigma factor in describing the connectivity. This sigma/connectivity is essential in connecting 'duplicate' cells in a simulator, describing the matrix, as well as the fracture porosities and permeabilities.

Fracture modeling in petrel consists of two main processes; creating discrete fracture network and scaling up fracture network properties (Figure 5).

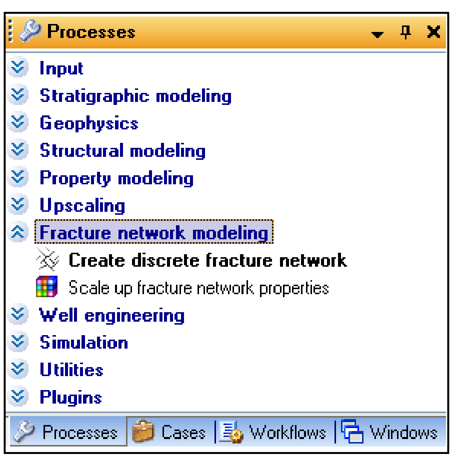


Figure 5 Fracture network modeling in processes tab

However, other standard processes in petrel are used prior to the fracture modeling, such as geometrical modeling and petrophysical modeling. Processes related to simulation are used after making the fracture model and properties.

Fracture modeling workflows are varied and are often customized for the conditions and the available data in a particular field. The workflow in petrel is designed to be flexible, giving user the power to use any available data.

Below is a common workflow sequence, which provides the novice user with an easy guide through the steps of generating a useful fracture model. For the experienced user, the petrel fracture workflow is open, providing versatility for specialized and customized workflows.

An example on the set up of a standard fracture model workflow is depicted below:

2.1 Step 1: Import, QC, and Display Fracture Interpretation from Wells

Import, QC, and display fracture interpretation from wells could be dip and azimuth interpretations from Image log data.

- A useful import format is 'Point well data (ASCII)'; where each attribute describes a fracture type and quality.
- Create tadpoles to show dip/azimuth data.
- Use Stereonet to visualize the fracture data.

2.2 Step 2: Data Analysis

1. Create new point attributes using calculator for rotation of dip relative to stratigraphic surface
2. Assign fracture sets using selection tools in stereonet
3. Generate fracture intensity logs (Figure 6)

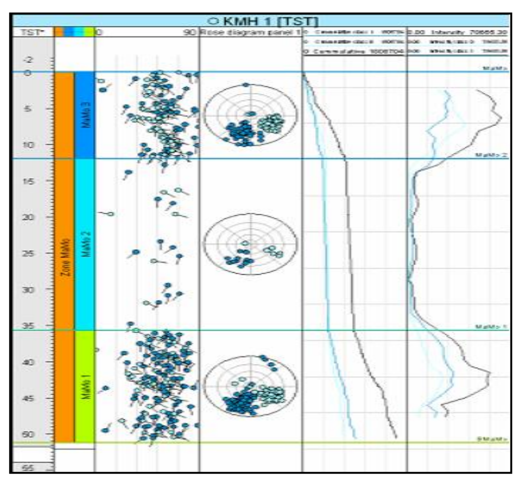


Figure 6 An example of data analysis

2.3 Step 3: Modeling Fracture Network Properties

- Upscale intensity logs and model intensity properties per fracture set

- Create fracture driver properties; can be used as secondary properties in co-kriging of the intensity model (Figure 7)

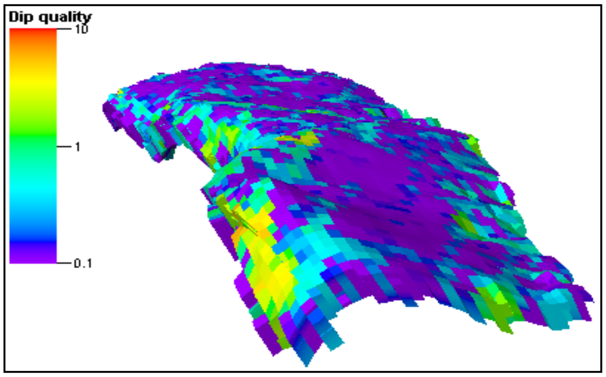


Figure 7 An example of the modeling fracture network properties

2.4 Step 4: Create Discrete Fracture Network (DFN)

1. Stochastic generation by sets using intensity property as input
2. Deterministic generation of fractures using fault patches from ant-tracking, fault surfaces, points or polygons
3. Generate fracture attributes (aperture and permeability) (Figure 8)

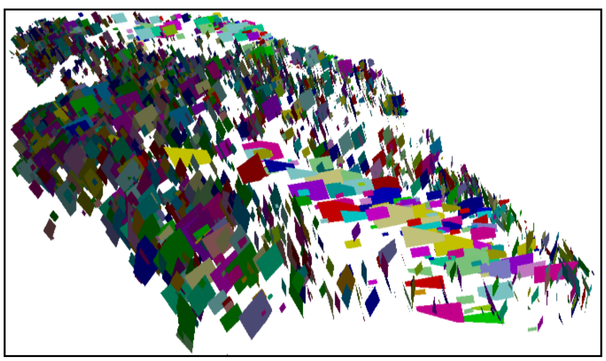


Figure 8 An example of the created discrete fracture network (DFN)

2.5 Step 5: Upscale DFN to Properties

1. Upscale fracture network properties (use statistical or flow based method)
2. The upscaling should be done onto a simulation grid (with less cells than the geo grid)
3. This will create property outputs that can be used in a simulation run (Figure 9)

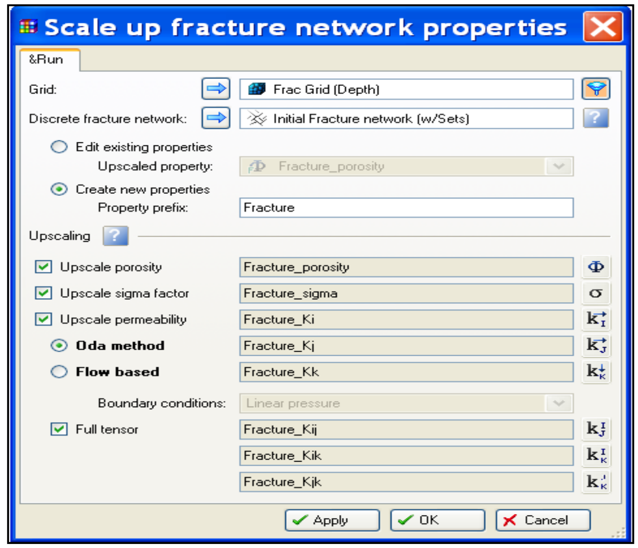


Figure 9 An example of upscaling DFN to properties

2.6 Step 6: Simulation

1. Set up a simulation run
2. Use matrix properties (standard properties) and fracture properties (from upscaling process) in dual porosity simulation (Figure 10)

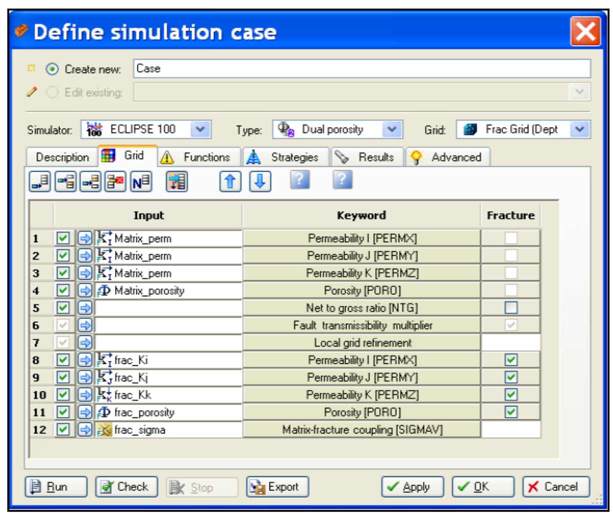


Figure 10 An example of setting up the simulation run

3.0 RESULTS AND DISCUSION

3.1 Available Dataset

- UGC map of Asmari formation
- Image logs of 12 wells (Figure 11)
- Fullset logs of 9 wells (Figure 12)
- Well tops of Asmari and Pabdeh formations
- Zonation data of 12 wells

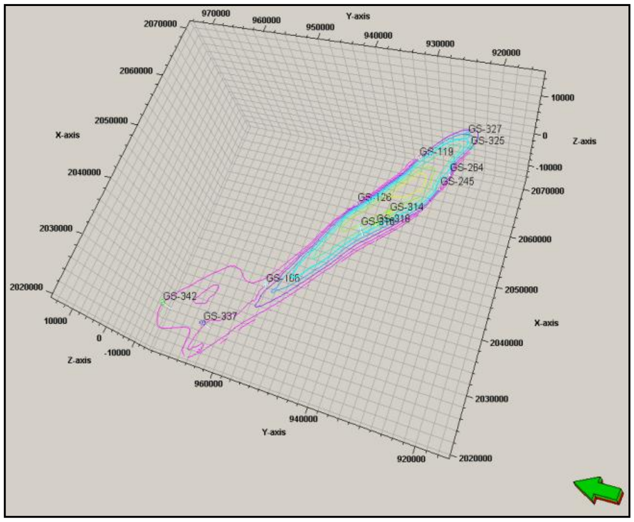


Figure 11 Image log data UGC map

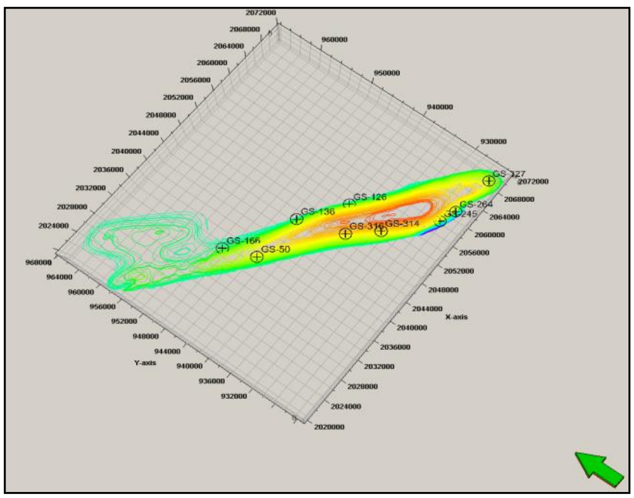


Figure 12 Fullset log data UGC map

3.2 Fracture Modeling

The purpose of the fracture modelling is to create simulation properties with the power to predict the behaviour of the reservoir (Figure 13).

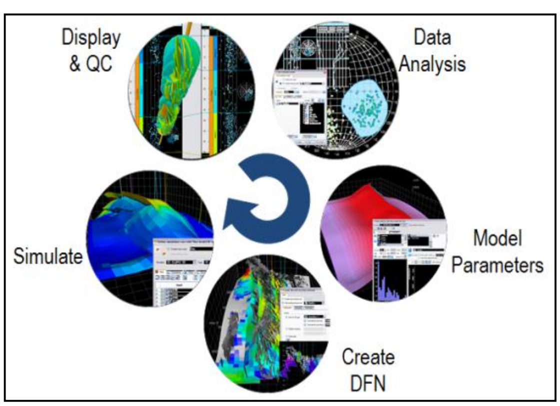


Figure 13 Fracture modelling procedure

3.2.1 Data Analysis – Well Data

Fracture data analysis (gs-166, gs-126, gs-119)

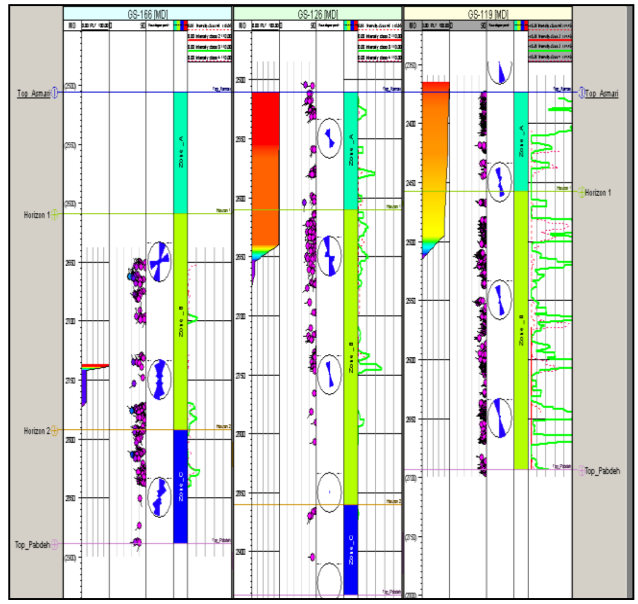


Figure 14 Fracture data analysis (GS-166, GS-126, GS-119)

Fracture Data Analysis (GS-245, GS-264, GS-325, GS-327)

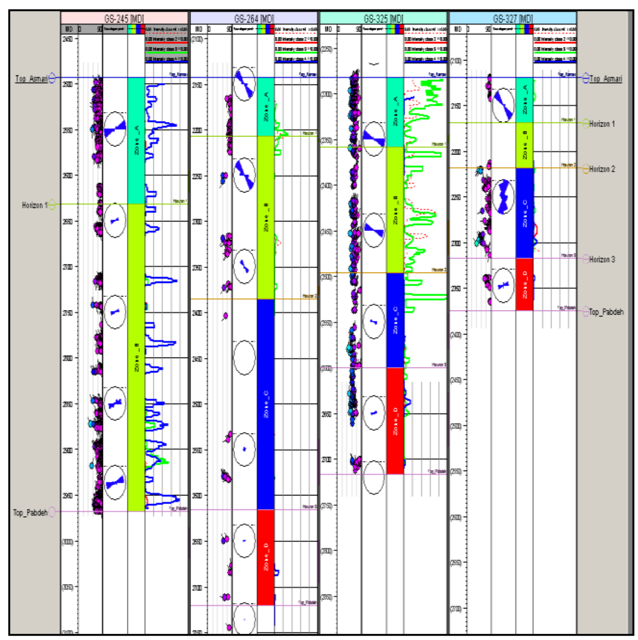


Figure 15 Fracture data analysis (GS-245, GS-264, GS-325, GS-327)

Fracture Data Analysis (GS-316, GS-318, GS-314)

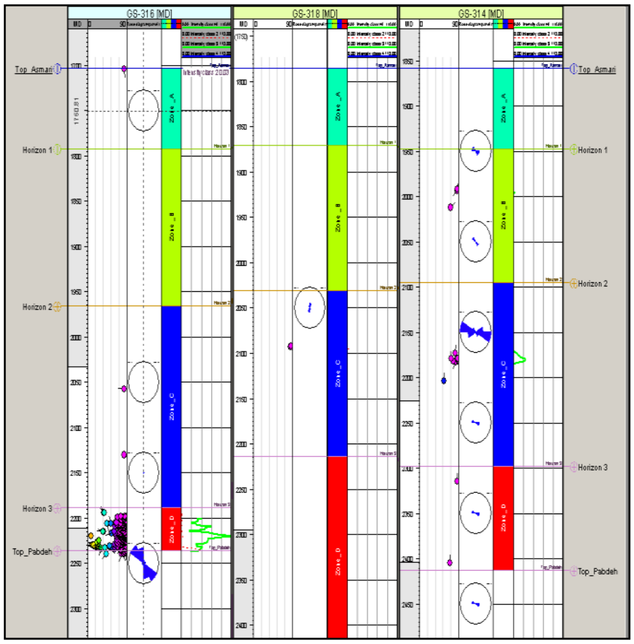


Figure 16 Fracture data analysis (GS-316, GS-318, GS-314)

Fracture Data Analysis (GS-342, GS-337)

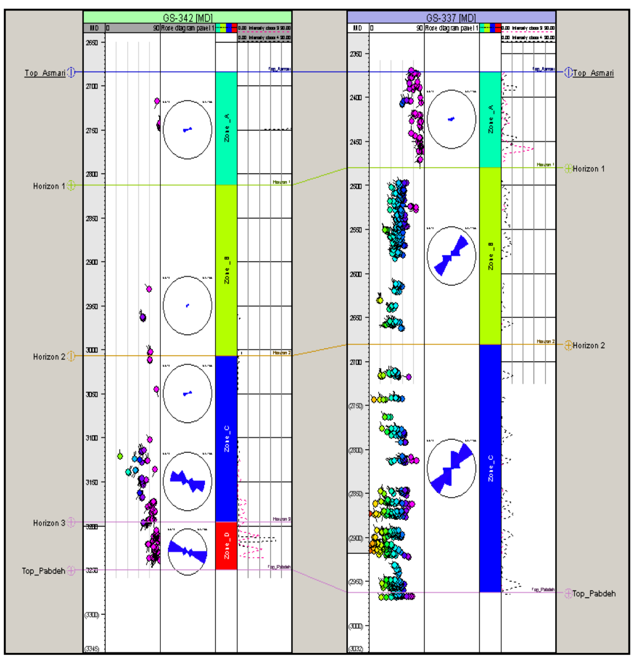


Figure 17 Fracture data analysis (GS-342, GS-337)

3.2.2 DFN Model of Gachsaran Field

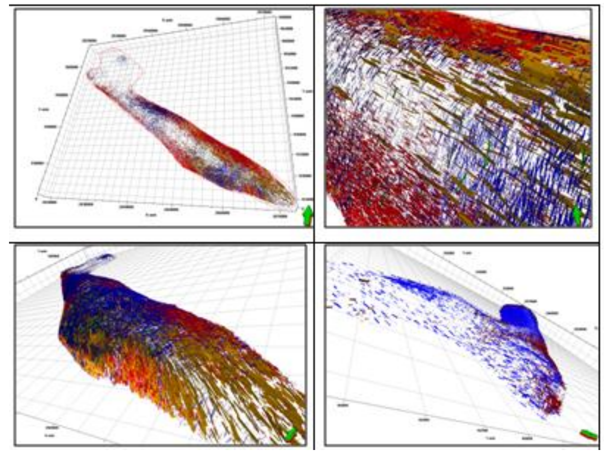


Figure 18 DFN model of Gachsaran field

3.2.3 DFN Model of Gachsaran Field-QC

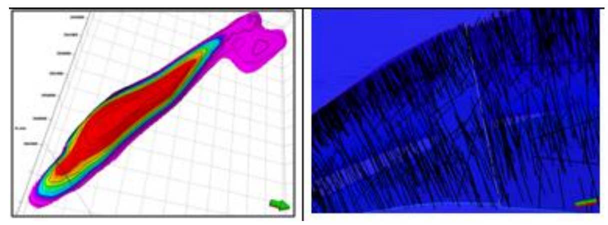


Figure 19 DFN Model of Gachsaran Field-QC

3.2.4 Fracture Properties

Fracture Properties for Segment1

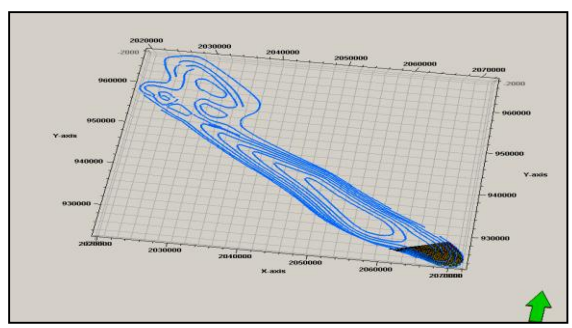


Figure 20 Fracture properties for segment1

Fracture Porosity

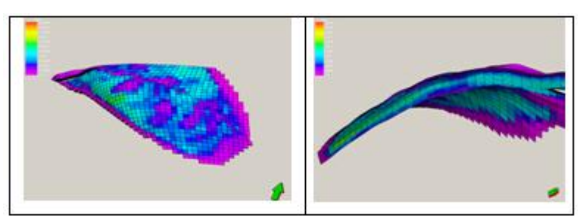


Figure 21 Fracture porosity for segment1

Fracture Permeability

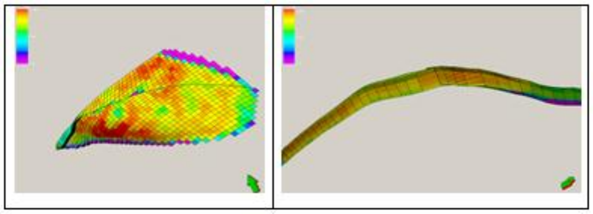


Figure 22 Fracture permeability for segment1

Statistics of Fracture Properties (Segment1)

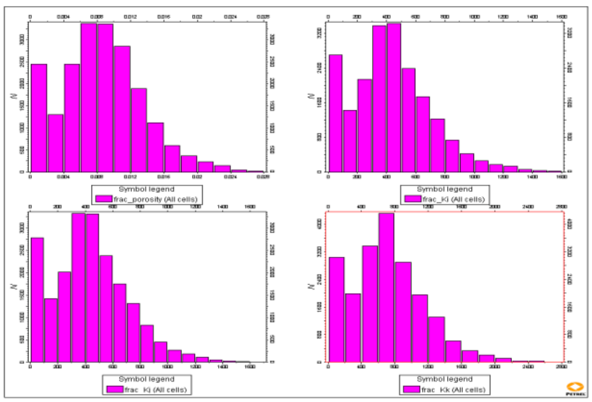


Figure 23 Statistics of fracture properties (Segment1)

Fracture Properties for Segment 4

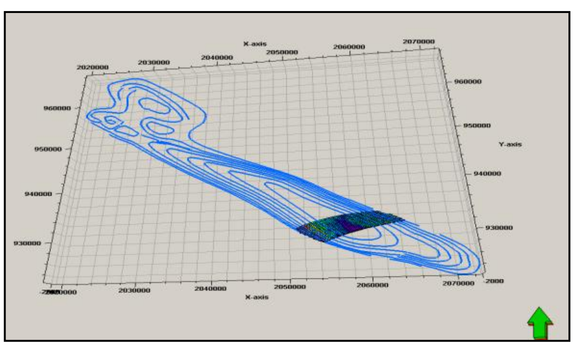


Figure 24 Fracture properties for Segment4

Fracture Porosity

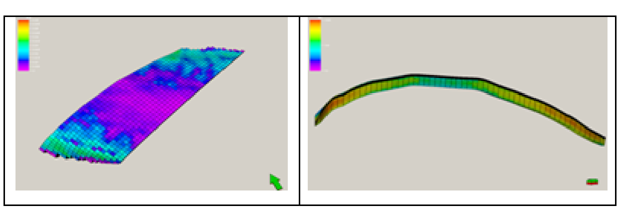


Figure 25 Fracture porosity forsegment 4

Fracture Permeability

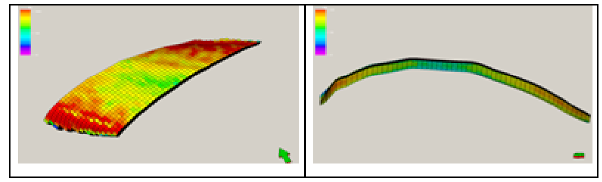


Figure 26 Fracture permeability for segment 4

Statistics of Fracture Properties (Segment 4)

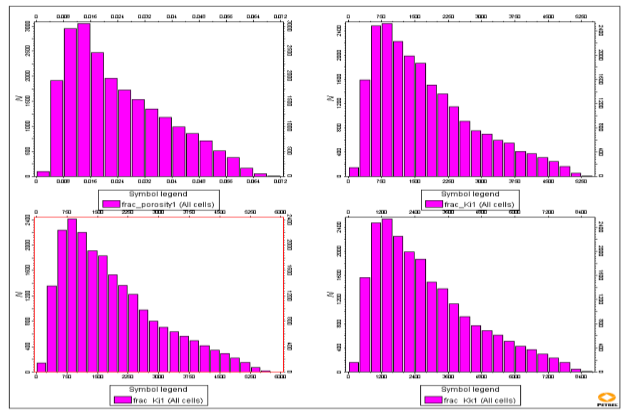


Figure 27 Statistics of fracture properties (segment 4)

3.2.5 Simulation

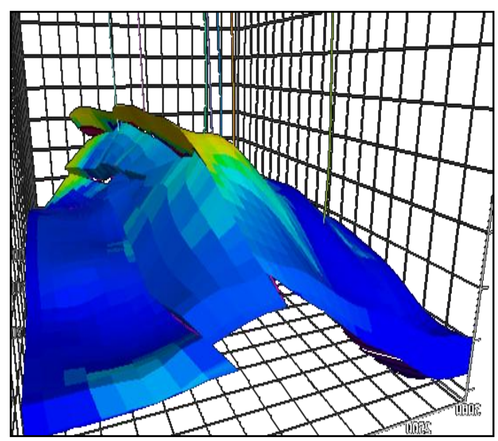


Figure 28 Simulation

When the fracture modelling job was done in this field, using the results of this job, the following information had been determined:

- The maximum dip inclination was near the Major fault and the minimum was in Lishter (10-80).
- The Thickness variation decreased towards the eastern part of the field.
- 9 faults had been distinguished in Gachsaran and Lishter.

- Longitudinal and oblique fractures were the most tectonic fractures.
- The longitudinal fractures were parallel to minimum stress (Zagros trend).
- The transverse fractures were perpendicular to the Zagros trend (near major fault).
- Fracture intensity was the nearest to the major fault and northern flank.
- Fracture porosity (0-7%).
- Fracture permeability (0-6000 md).

4.0 CONCLUSION

In this work, the fracture modelling job was done in one of the most important Iranian oil and gas fields, Gachsaran field. The data used in this work were image loge data in cooperation with other geological logs data, while the software used for this work was petrel software. It was found that the maximum dip inclination had been near major fault and the minimum was in Lishter (10-80), whereas the thickness variation decreased towards the eastern part of the field, 9 faults had been distinguished in Gachsaran and Lishter, longitudinal and oblique fractures were the most tectonic fractures, the longitudinal fractures were parallel to minimum stress (Zagros trend), the transverse fractures were perpendicular to zagros trend (near major fault), the fracture intensity was the nearest to the major fault and northern flank, the fracture porosity was (0-7%), and the fracture permeability was (0-6000 md).

Acknowledgement

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