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Identifying the high potential zones for hydraulic fracture propagation / Eastern Baghdad field

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Abstract

For a reservoir with high storage capacity and low ability to produce, the serious problem is the sharp reduction in the recorded well productivity within a short period. One solution to this problem is to create hydraulic fractures that increase formation permeability and keep its production at high rates for a sufficient time. The field under study is the East Baghdad oil field of three formations: Saadi, Tanuma, and Khasib. Knowing the geomechanical behavior of these reservoirs has a critical effect on the success of hydraulic fracturing operations. In this study, rock stress magnitude and direction, rock elasticity, rock strength to fracturing initiation, and all these parameters in addition to petrophysical properties will be used to identify whether the hydraulic fracturing operation could be successful or not. An integrated modeling of the studied reservoir is an essential step including 1-D geomechanical evaluation of many formations in order to choose the perfect layer to create hydraulic fracture. Then, a 3-D distribution of geomechanical properties and petrophysical properties was presented to make a perfect selection of these properties. The geomechanical evaluation of the reservoirs under study is supported by experimental evaluation of core samples including Energy Dispersive X-ray spectroscopy (EDS), Scanning Electron Microscopic (SEM) image, and thin section (TS) image. The results show that a reduction in the calculated geomechanical properties in terms of Poisson ratio young modulus and compressive strength are favorable for candidate layer selection. Among the studies of rock mechanical properties, it is also noticed that unconfined compressive strength is a crucial parameter for best layer selection. The suitable depths for fracturing jobs are given in detail in this study using brief data collected from four wells.

Keywords: *3-D Mechanical earth model; Hydraulic fracturing; Scanning electron microscopic; Thin section; Perfect layer; Geomechanics.*

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1- Introduction

One of the most important stages in hydraulic fracturing operation planning is to detect the perfect layer based on the rock's ability to fracture initiation and propagation. Perfect layer choice may depend on both reservoir and geomechanical quality. The estimation of both the mechanical and physical properties of rocks is an essential issue in reservoir development applications. hydraulic fracturing is one of the most common and practical economic stimulation techniques for increasing hydrocarbon production and recovery. Experimental examination of the rock is an essential step in successful geomechanical evaluation for perfect layer choice [1]. Hydraulic fracturing technology is now a well-refined process, both theoretically and practically. This technology has had a significant evolution, transitioning from individual operations to widespread use in the production of hydrocarbons. A prevalent issue in reservoir fluid dynamics research is the absence of techniques that allow for the direct observation or measurement of parameters that determine certain flow phenomena or processes in a reservoir [2]. The impact of geomechanical factors in selecting a perfect well's location was explained in a 3-D map and perfect layer choice based on 1-D mechanical evaluation [3]. Many criteria are advised in the literature to determine candidate intervals for the hydraulic fracturing simulation model. Field development relies on using static reservoir characterization, which contains the initial stress distribution and the mechanical properties of the field along with the numerical modeling of the reservoir to evaluate the dynamic development of stresses [4-6]. Rock mechanics can help the oil and gas sector advance and increase ROI [7]. introduce that the distribution of rock mechanical characteristics along the depth of the wells is critical for many reservoir geomechanics applications.

In general, rock fracability can be defined in different oil reservoirs by understanding the failure mechanism, geomechanical background, and the most important factors that could affect fracability results [8]. Many factors, including in-situ stress, mechanical characteristics, and operational factors related to fracturing fluids, influence the shape, orientation, and propagation of hydraulic fractures, as indicated by [9-10]. The most crucial geomechanical parameters influencing the layer selection are the horizontal stress and unconfined compressive strength (UCS) [11]. horizontal

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stress has proven to be more effective and increased the production contribution of each stage [12]. Using the three principal stresses, formation stress is characterized. To overcome these challenges, the initial step in quantifying rock mechanical properties for reservoir geomechanics-related applications is the dynamic determination of these properties [13]. As a result, the major stresses at the wellbore wall can be represented by an infinite hollow cylinder. the magnitude of horizontal stress σh can be approximated using the well-known poroelastic theory, which connects Poisson's ratio (v) and effective vertical stress. Propagation of the fracture to surrounding layers, the need for high pressure to create the fracture, weak fracture conductivity because of high stress applied on fracture faces, and loss of fracturing fluid are some consequences of poor candidate selection [14]. Many failure criteria, including Mohr-Coulomb, Mogi-Coulomb, and modified Lade, were employed to predict the potential rock collapse surrounding the wellbore. The most popular criterion for wellbore breakout is the 2D Mohr-Coulomb failure criterion, which assumes a linear increase between minimum and maximum stresses and ignores intermediate stresses that may give the rock more strength[11-15]. As a result, researchers found the Mohr-Coulomb criterion to be a deficient and conservative assessment of appropriate mud pressure [16].

In this study, the interested field is the East Baghdad oil field which is about 10 km to the east of Baghdad city. Saadi, Tanuma, and Khasib formations are essential reservoirs within this field due to the large amounts of hydrocarbons contained by these reservoirs. The production section in the studied area consists mainly of carbonate rocks including Saadi, Tanuma, and Khasib reservoirs. It's postulated that the Saadi formation is an upper Cretaceous deposit approximately 100 m thick and can be found at depths ranging from 2100 to 2500 m consisting mainly of limestone. This formation has heterogeneous characteristics and varied petrophysical property behavior with stress. The Gross vertical thickness of the Saadi, Tanuma, and Khasib formations is about 135 m, 120m, and 125m respectively. These formations contain high porosity and low permeability, which causes a decrease in the production rate over time. The reservoir's nature makes development challenging the success of any proposed development plan is highly dependent on the selection of suitable layers for vertical well placement and the identification of optimal hydraulic fracturing design criteria. Fig. 1 shows the stratigraphic columns of the studied reservoirs in the interested field.

2- Experimental rock evaluation

Thin section (TS) and Scanning electron microscope (SEM) are a useful tool for accurate estimation and evaluation of rock mechanical properties. The sample used in this test is a cutting sample and has an irregular shape. TS is a testing conduction for very thin materials of the rock samples. This test includes measuring the surface of a component, small pieces, or small areas of the sample and measuring individual microstructures. The resulting image can be used to describe rock microfacies and pore-shape geometry. This test has been conducted in the current study for two samples from Khasib and Tanuma layers as shown in Fig. 2. The Tanuma formation sample described by TS consists of cistconsistsrite more than 4um and it is selectively recrystallized to micmicrosite, it consists of representing 100% Calcite, 65% including Groundmass and 35% Fossils Iron and so that rock is Carbonate as shown in Fig. 2 b. While Khasib formation sample consists of micrite of more than 4um and it is selectively recrystallized to microsparite as shown in Fig. 2 a. Mineral constituents represent 100% Calcite, 70% including Groundmass and 30% Fossils Iron. Depending on this test classify The rocks are carbonate rocks. Scanning Electron Microscope (SEM) provides structural explanations for the sample's behavior. It has samples that show a normal trend in the permeability-stress relationship in the Tanuma / Khasib reservoir. One layer appears to have low sensitivity of these core samples to stress is illustrated in Fig. 2 to Fig. 4 below by tests SEM and TS, Fig. 3 represents the device that was used in the SEM test. caused by the sample content of vuggy pores partially filled with sparry calcite.

For EDS analysis which gives the mineral causes to the sample's behavior. To understand properties behavior with stress, the test of rock mineralogy EDS results was considered, this test provides weight percent mineralogy. The stress-dependent behavior of rocks is influenced by their mineral composition due to the mechanical characteristics of ductility and brittleness [18], illustrated in Table 1 and Table 2. Note, the TS test has been performed in Geological Survey Authority and SEM, and EDS performed in Al-Khora Company.

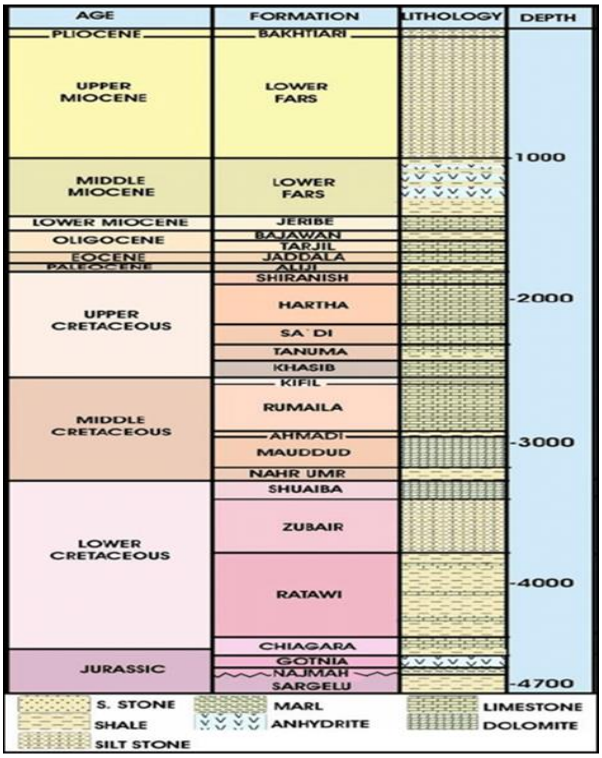
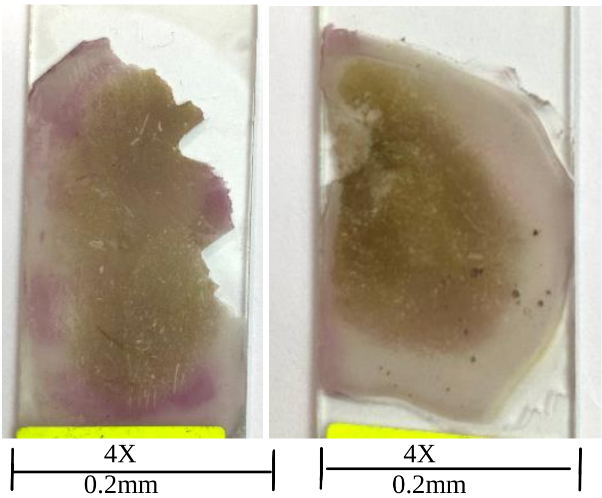


Fig. 1. Stratigraphic Column of The East Baghdad Oil Field [17]



(a) (b)

Fig. 2. Microscopic Photo (a) of Khasib (b) of Tanuma Formations

Fig. 3. SEM Test Device

Table 1. EDS Mineralogy of Khasib Formation

Element	Atomic %	Atomic % Error	Weight %	Weight % Error
C	38.1	0.3	28.8	0.3
O	55.9	0.6	56.4	0.6
Mg	0.3	0.0	0.5	0.0
Al	0.1	0.0	0.1	0.0
Si	0.1	0.0	0.3	0.0
S	0.1	0.0	0.3	0.0
Ca	5.3	0.0	13.4	0.1
Ni	0.0	0.0	0.2	0.0

Table 2. EDS Mineralogy of Tanuma Formation

Element	Atomic %	Atomic % Error	Weight %	Weight % Error
C	44.6	0.4	34.9	0.3
O	50.5	0.6	52.6	0.6
Mg	0.2	0.0	0.3	0.0
Al	0.1	0.0	0.1	0.0
Si	0.2	0.0	0.3	0.0
S	0.1	0.0	0.1	0.0
Cl	0.0	0.0	0.1	0.0
Ca	4.4	0.0	11.6	0.1

3- Mechanical rock and petrophysical property

Various correlations can be utilized to extract mechanical properties from petrophysical logs, which are then used to compute the magnitude of stresses. The study of geomechanics examines how applied stresses and variations in temperature, pressure, and other environmental variables cause rocks and soils to deform. The geomechanical analysis depends on a comparison between the mechanical properties and rock strength with the in situ stresses. The in-situ stresses play key parameters in different stages of the well or the reservoir life, such as well planning, well construction, and well production and injection as mentioned [19]. Before studying rock failure and stress analysis, in-situ stresses must be known. In general, the in-situ stresses can be divided into three main stresses that are perpendicular to each other, two are horizontal and the other one is perpendicular to them. That modulus characteristics show how strong and stable rocks are under various circumstances [20]. Sonic logging, which includes both compressional and shear acoustics, as well as a formation bulk density log, is one of the most important and available methods for estimating dynamic rock mechanical parameters.

4- 1-D Mechanical earth model

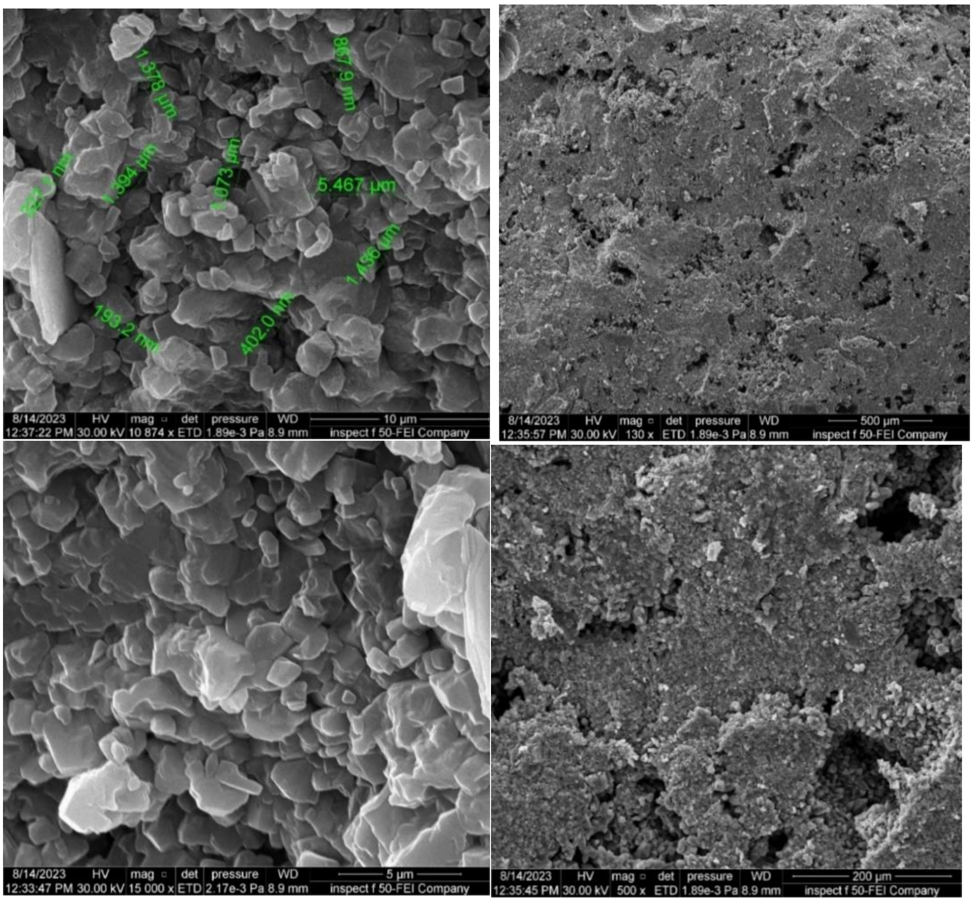
For adequate detection of the candidate layer selected for adjusting hydraulic fracturing operation, four deviated wells are considered in the current study for accurate evaluation of different stress values using Techlog software. The required data for constructing 1D MEM pertinent are; Bulk density, sonic log (compression and shear), porosity, and Gamma ray. During the construction of the mechanical model, several empirical correlations and physical equations were employed to forecast the mechanical and elastic formation properties [20]. The calculating process and output results for the investigated four wells are described briefly in this section.

The vertical stress applied to the formation thickness is equal to the weight of the vertical rock column above it and is then called the overburden [20].In this study miller method was chosen based on its useful parameters as shown in Eq. 1 and Eq. 2.

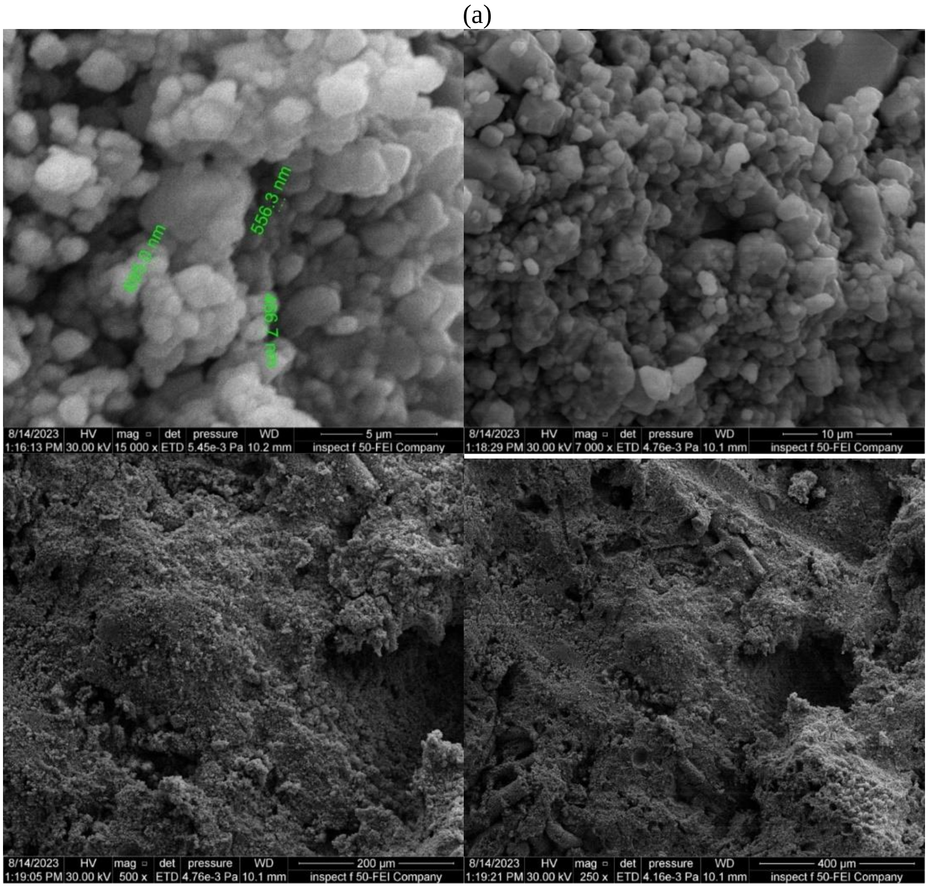
$$\rho_{Miller} = \rho_{matrix}(1 - \emptyset_{Miller}) + \rho_{water}\emptyset_{Miller} \quad (1)$$

$$\emptyset_{Miller} = \emptyset_a + \emptyset_b e^{(-k*(TVD-AirGap-WaterDepth)1/N} \quad (2)$$

The Pore pressure is used as a key parameter for estimating the in-situ horizontal principal stresses and for forecasting safe mud weights for drilling stable wellbores without any expected results associated with wellbore collapse or wellbore failure [21]. Pore pressure was calculated using the Eaton method and sonic log data for the four studied wells.



(a)



(b)

Fig. 4. (a) Thin Section for Tanuma Formation, (b) Thin Section for Khasib Formation

The dynamic elastic properties are calculated assuming isotropic, homogeneous, and elastic rocks using compression sonic (DTC) and shear sonic (DTS) and density logs (ρb) In this research sonic and density log data are used to determine and analyze rock dynamic mechanical properties, including the Young Modulus E, shear modulus G, and Poisson's ratio υ. The calculation results are depicted in the Fig. 5 to Fig. 8 for each well.

In terms of horizontal stresses, many authors contend that the minimal horizontal stress σh can be compared to leak-of-test (LOT) data if available (Kung et al., 1994). Vertical stress σv (equal to Pov–Pp) and horizontal stress σh are determined for each well by Eq. 3 explained in Fig. 5 to Fig. 8 for each well.

$$\sigma h = \frac{v}{1-v}\sigma v - \frac{v}{1-v}\alpha P_p + \alpha p_p + \frac{V}{1-V^2}\varepsilon_x + \frac{Ev}{1-v^2}\varepsilon_y \qquad (3)$$

The most important mechanical metrics of a formation are the uniaxial compressive strength (UCS), static Young's modulus (Es), and Poisson's ratio (s). These parameters describe how rock varies or fractures when it is under stress, and they can be estimated both statically and dynamically. That is the equation Eq. 4 to Eq.7 has been used to determine the dynamic Young's modulus, Poisson ratio, bulk modulus, and shear modulus, respectively. Concerning the static elastic properties, it has been estimated using the correlations in the software [22].

$$E_{dyn} = \frac{9 * G_{dyn} K_{dyn}}{G_{dyn} + 3K_{dyn}} \qquad (4)$$

$$v = \frac{3K_{dyn} - 2G_{dyn}}{6K_{dyn} + 2G_{dyn}} \qquad (5)$$

$$K_{dyn} = 13474.45 * \left[\frac{\rho b}{(\Delta tshear)^2}\right] - \frac{3}{4} * G_{dyn} \qquad .(6)$$

$$G_{dyn} = 13474.45 * \frac{\rho b}{(\Delta tshear)^2} \qquad (7)$$

Eq. 8 was used to determine the static Poisson's ratio and static Young's modulus was calculated based on the John Fuller correlation [23].

Where: σv vertical stress, psi, ρb bulk density, g/cc, H total depth, m, $\Delta tshear$ sonic shear velocity, µs/ft, $Edyn$ dynamic young modulus, Mpsi, $Gdyn$ dynamic shear modulus, Mpsi, $Kdyn$ dynamic bulk modulus, Mpsi, $vdyn$: Dynamic Poisson's ratio, unitless, $vsta$: Static Poisson's ratio, the PR multiplier factor of Eq. 8.

$$v_{sta} = v_{dyn} * PRmult \qquad (8)$$

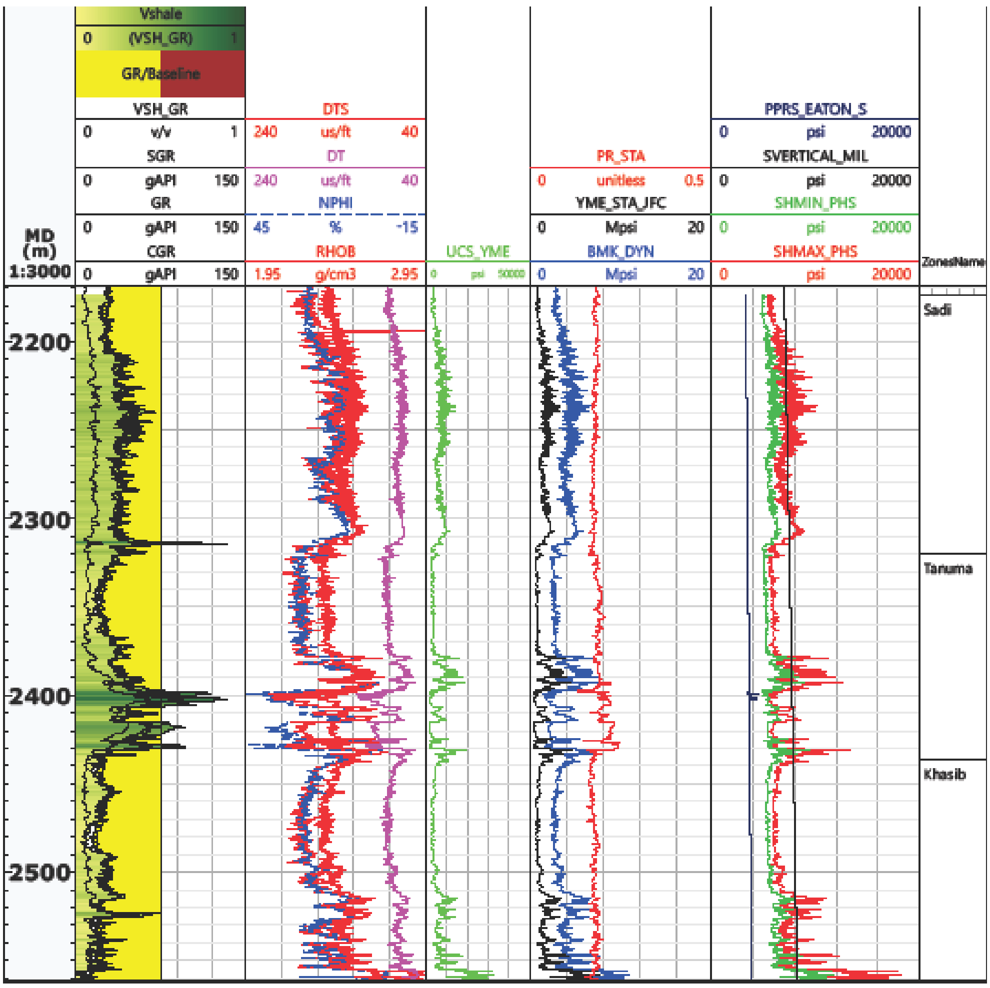


Fig. 5. Estimate Rock Mechanical Properties and Horizontal Stresses for Well A

The uniaxial compressive strength (UCS) proposal has been put up, based on studies from various fields, wherein the correlation between (UCS) and different well logs or elastic properties [16]. We can choose the suitable correlation, which is more pertinent to the research field to estimate UCS of formation Eq.9. Eq.10 is employed to change the sonic travel time to compressional wave velocity where Vp is the P-wave velocity in Km/sec, and Δt is the sonic time in µsec/ft. Depending on the Gamma-ray log, the internal friction angle is rock strength (TS) were calculated as a function of internal friction angle and rock strength. Such correlations are estimated for the Saadi, Tanuma, and Khasib formations.

$$UCS = 2.28VP + 1.939 \quad (9)$$

$$V_p = \frac{0.3048*10^6}{\Delta t*1000} \quad (10)$$

5- 3-D MEM constructing

In this study, a three-dimensional geomechanical model was constructed for an accurate areal description of reservoir geomechanical properties. Three reservoirs were taken into consideration during property distribution which are the Saadi, Tanuma, and Khasib formations. These formations were divided into 8, 15, and 10 layers, respectively according to lithological variation. This division helps to distribute properties more accurately as shown in Fig. 9. It Depends on the data preparation, including the contour map, well tops, formations tops, and the heads of each well. In addition to the results of geomechanical properties from TECHLOG. The geomechanical properties obtained from TECHLOG software were imported to Petrel software in order to build a three-dimensional geomechanical model (3D MEM). These important data are Young modulus, Poisson's ratio, unconfined compressive strength UCS, vertical stress σv, maximum horizontal stress σ_H, and minimum horizontal stress σh. In this study, the 3D structure model has been built based on the fault model. The inserted polygon to the model is constructed according to the points of the formation contour maps 2D grid surfaces which were created depending on map data points, line data, polygons, surfaces maps, and well tops. First of all, these properties were upscaled for each well utilizing the arithmetic technique (simple method) based on the results that are uniform with the good logs as shown in Fig. 9. The Constructing 3D MEM enables us to distribute all the estimated 1D MEM parameters between wells throughout the formations. Fig. 10 to Fig. 27 show a 3-D distribution of permeability, porosity, water saturation, Young modulus, Poisson's ratio, UCS, and stresses. These 3-D geomechanical model maps are helpful to identify zones of high potential for hydraulic fracturing and identify the best location to drill well for each formation.

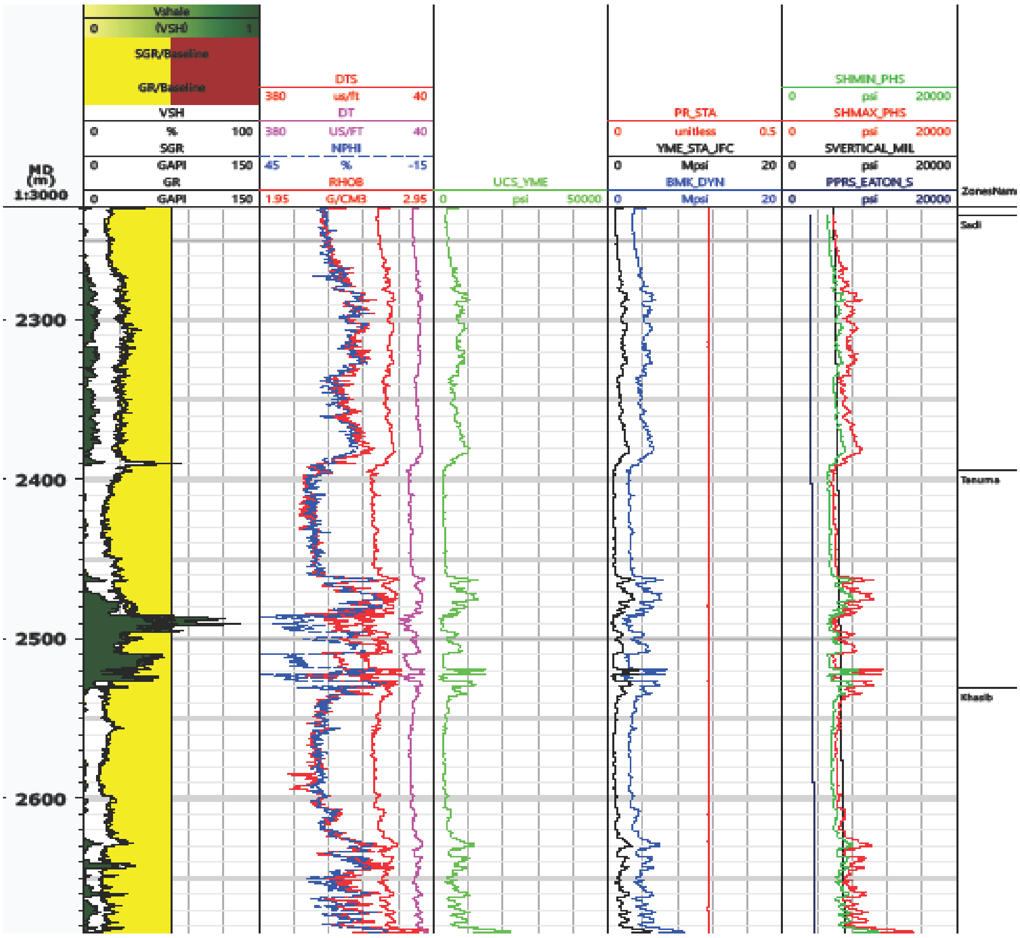


Fig. 6. Estimate Rock Mechanical Properties and Horizontal Stresses for Well B

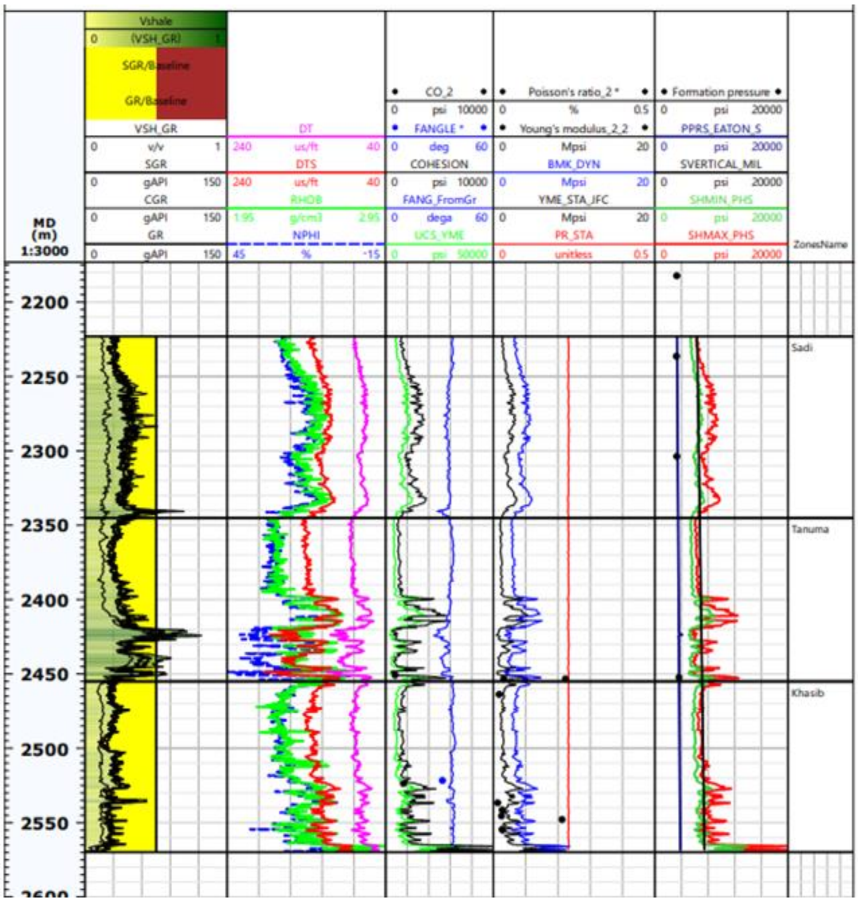


Fig. 7. Estimate Rock Mechanical Properties and Horizontal Stresses for Well C

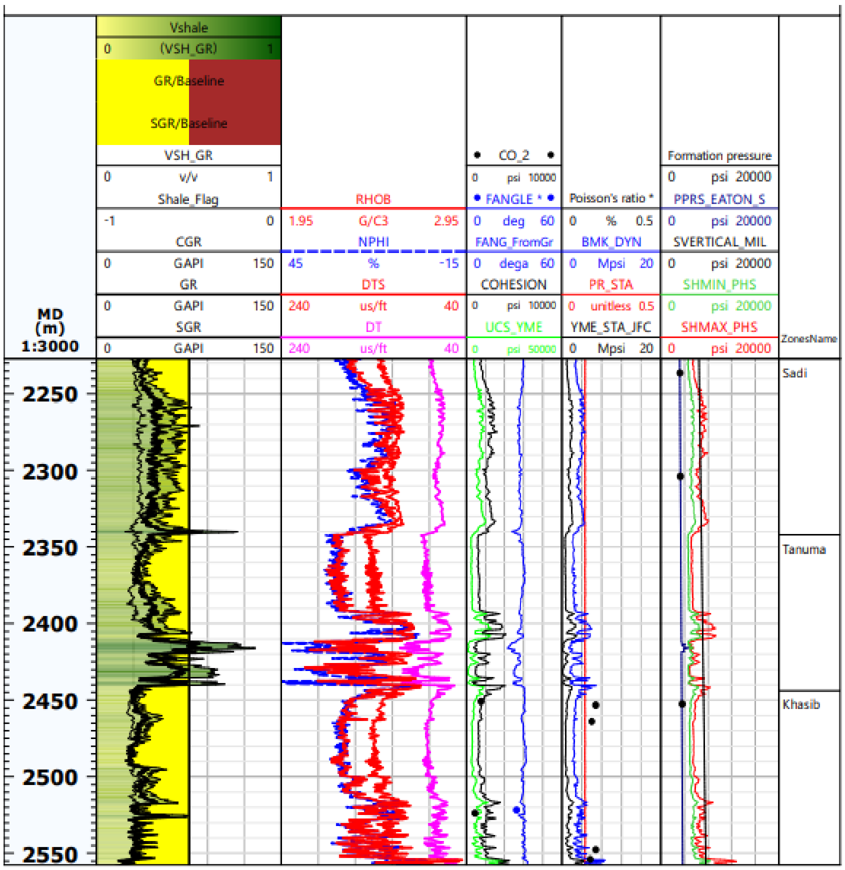


Fig. 8. Estimate Rock Mechanical Properties and Horizontal Stresses for Well D

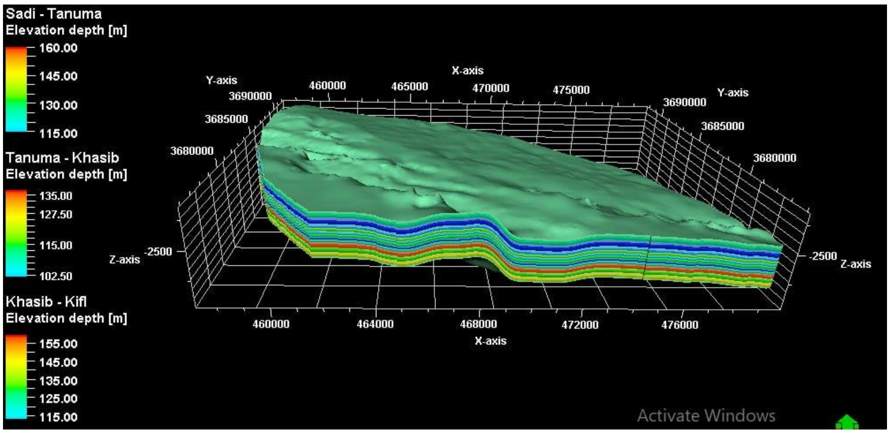


Fig. 9. 3D MEM Modeling

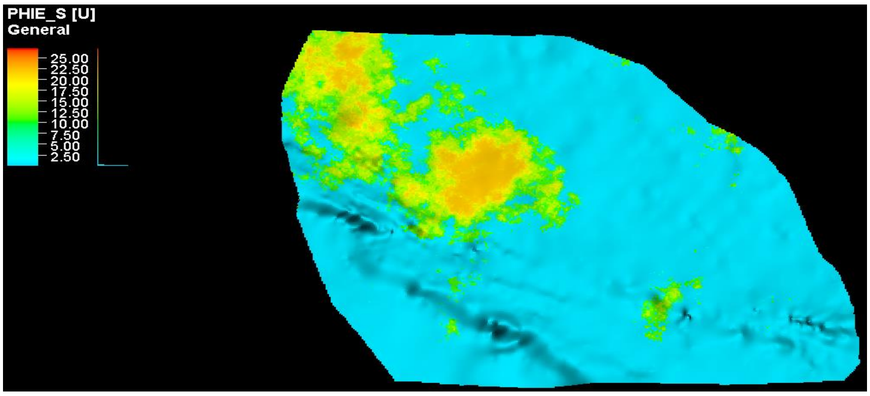


Fig. 10. 3D Porosity Distribution Modeling of Saadi Formation

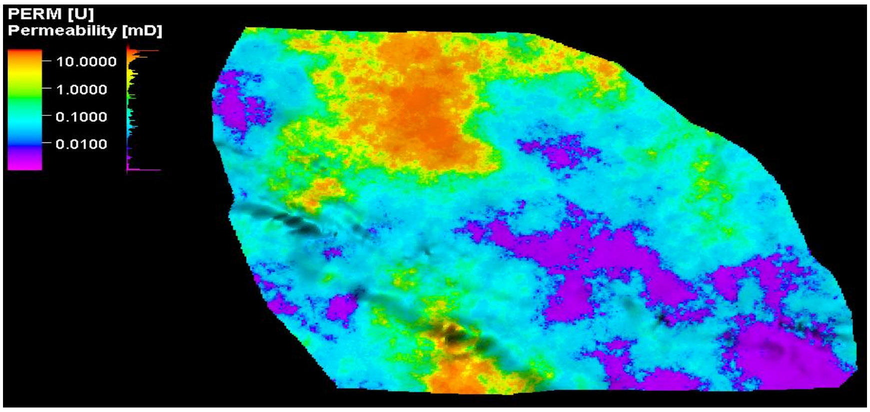


Fig. 11. 3D Permeability Distribution Modeling of Saadi Formation

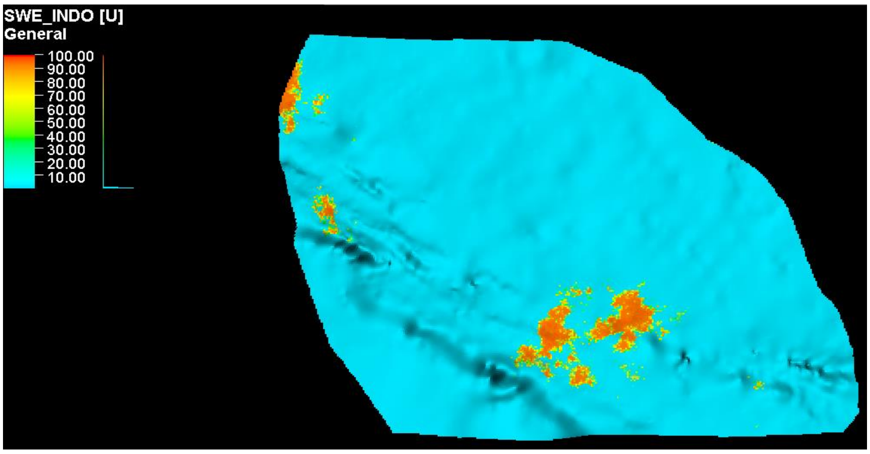


Fig. 12. 3D Water Saturation Distribution Modeling of Saadi Formation

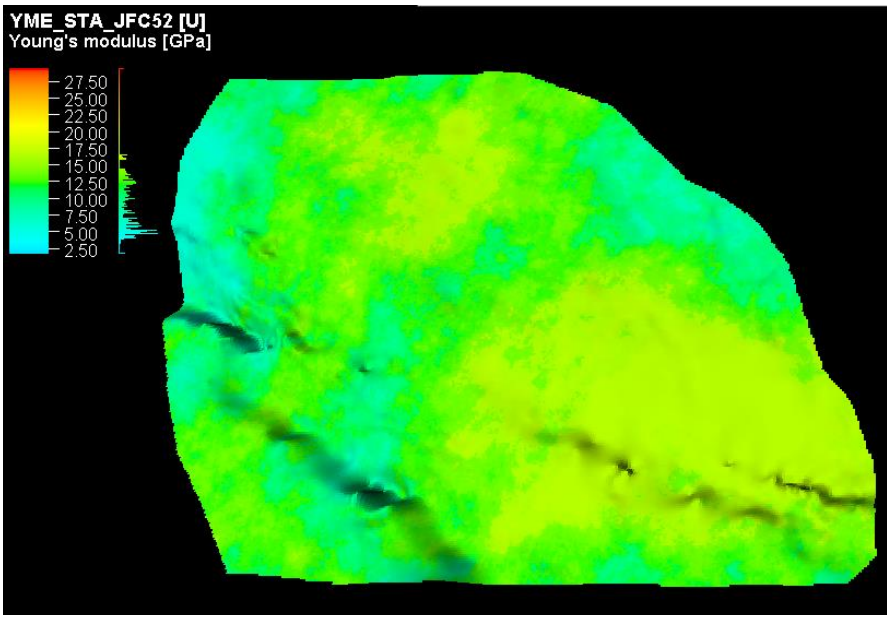


Fig. 13. 3D Young Modulus Distribution Modeling of Saadi Formation

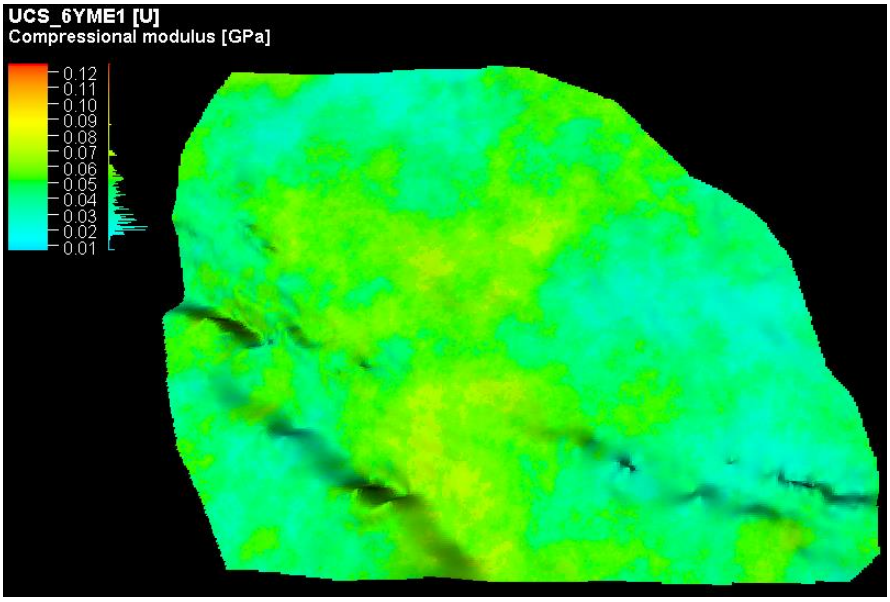


Fig. 14. 3D UCS Distribution Modeling of Saadi Formation

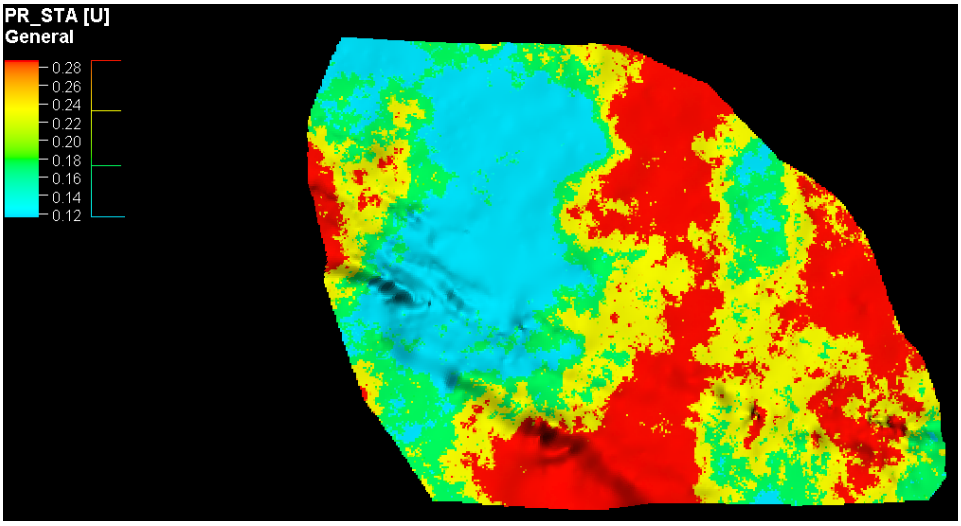


Fig. 15. 3D Poisson's Ratio Distribution Modeling of Saadi Formation

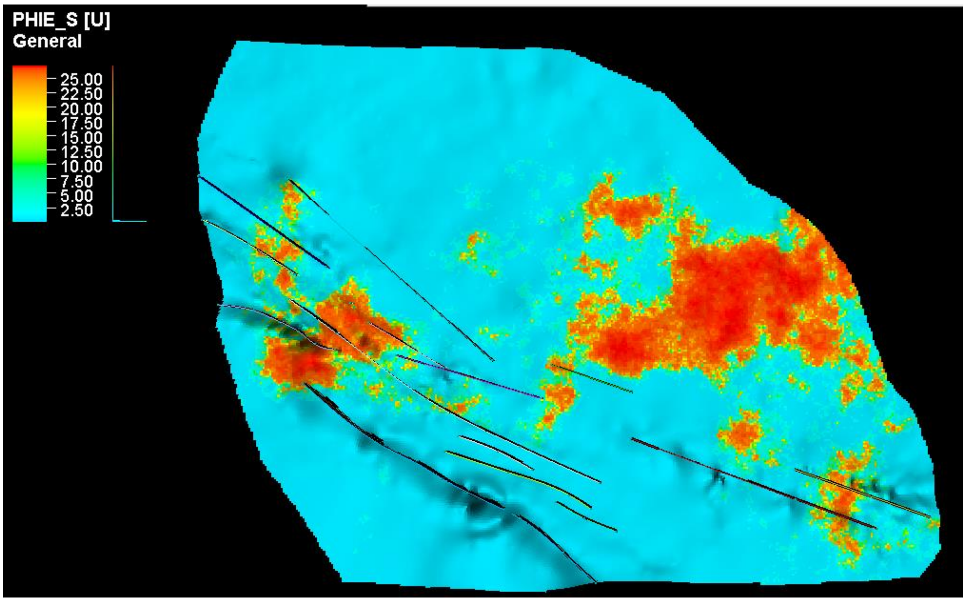


Fig. 16. 3D Porosity Distribution Modeling of Tanuma Formations

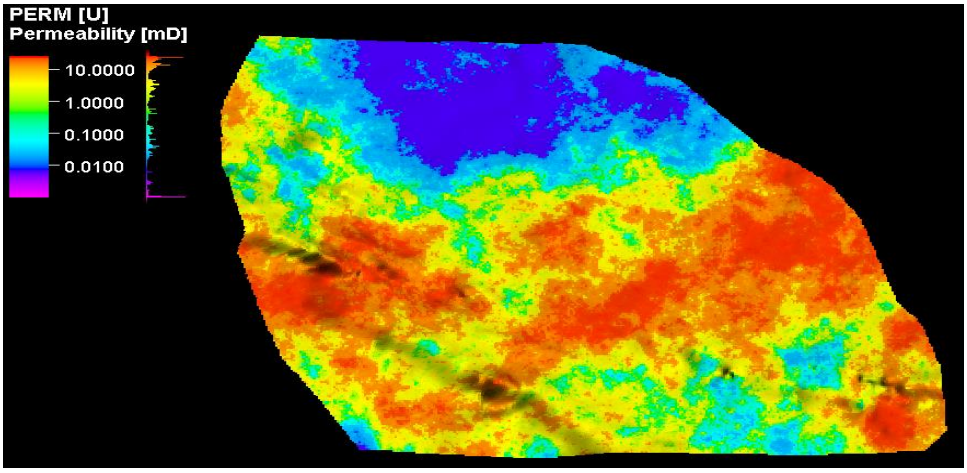


Fig. 17. 3D Permeability Distribution Modeling of Tanuma Formations

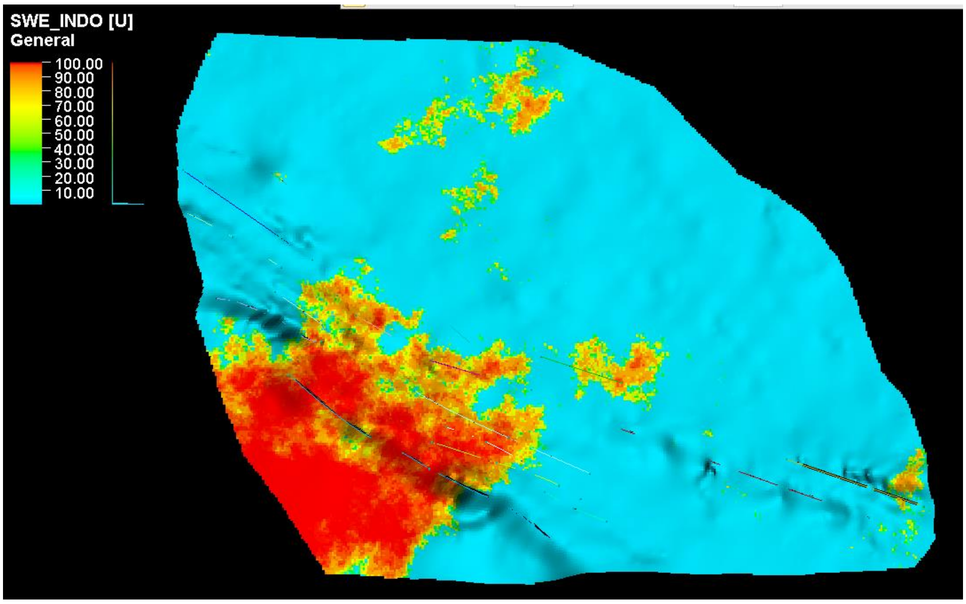


Fig. 18. 3D Water Saturation Distribution Modeling of Tanuma Formations

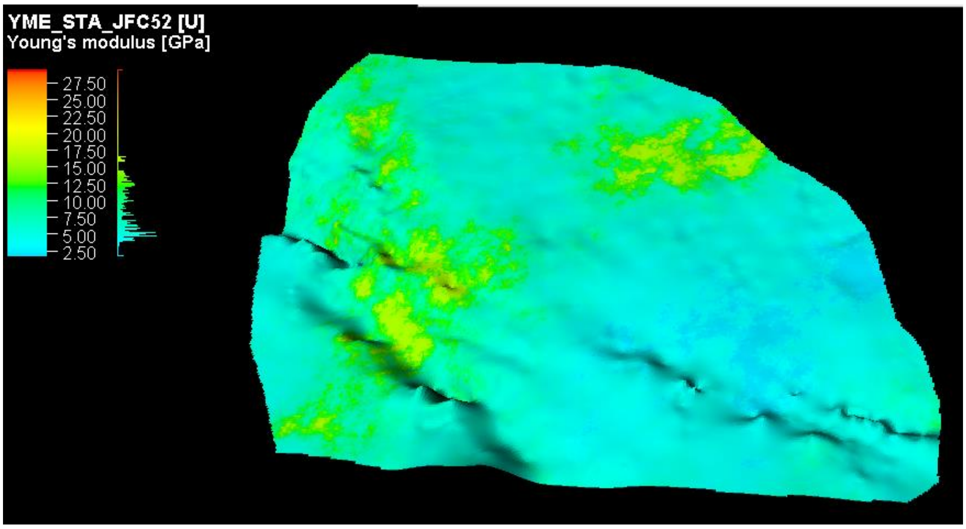


Fig. 19. 3D Young Modulus Distribution Modeling of Tanuma Formations

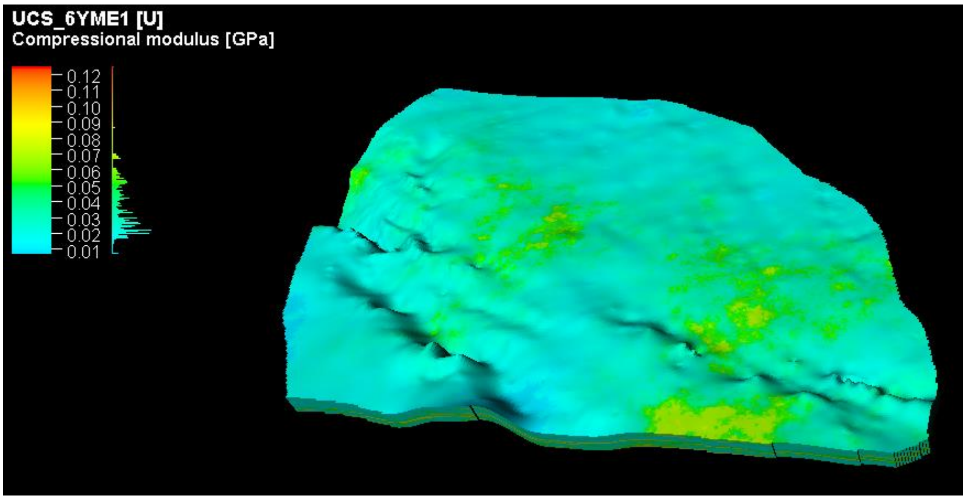


Fig. 20. 3D UCS Distribution Modeling of Tanuma Formations

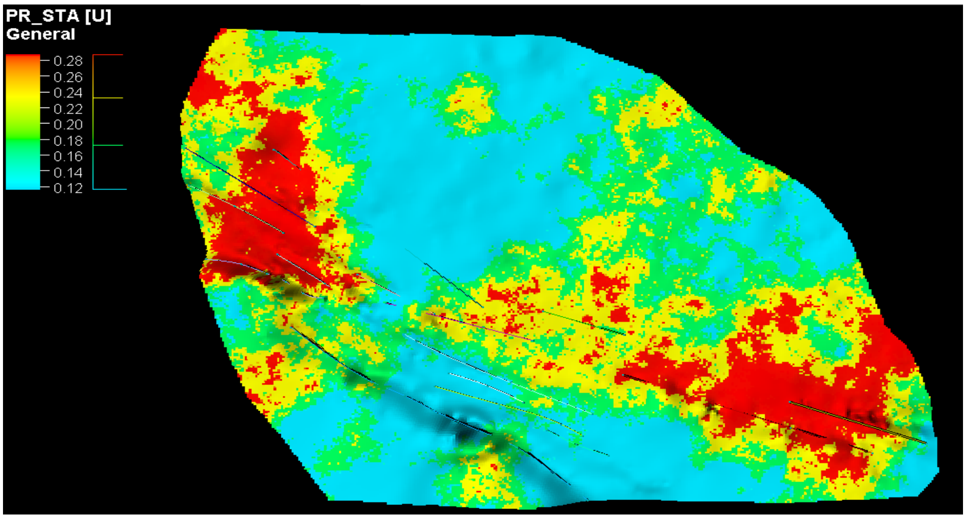


Fig. 21. 3D Poisson's Ratio Distribution Modeling of Tanuma Formations

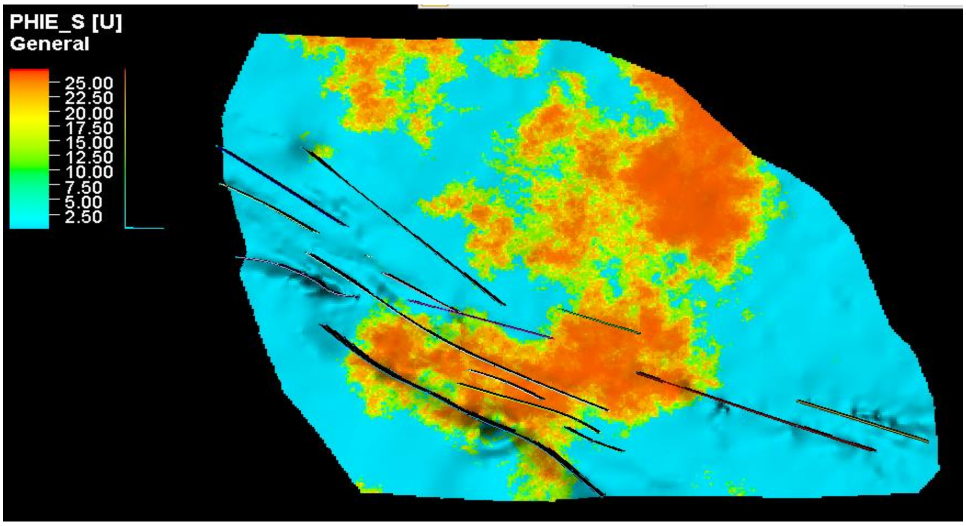


Fig. 22. 3D Porosity Distribution Modeling of Khasib Formation

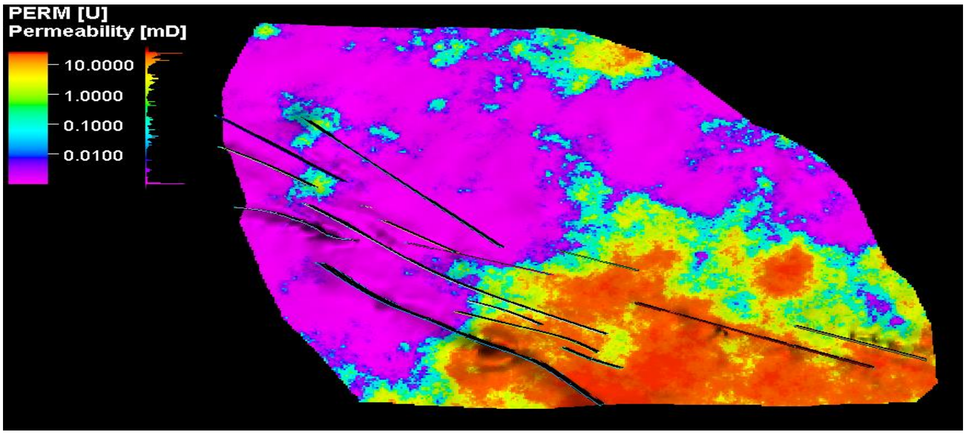


Fig. 23. 3D Permeability Distribution Modeling of Khasib Formation

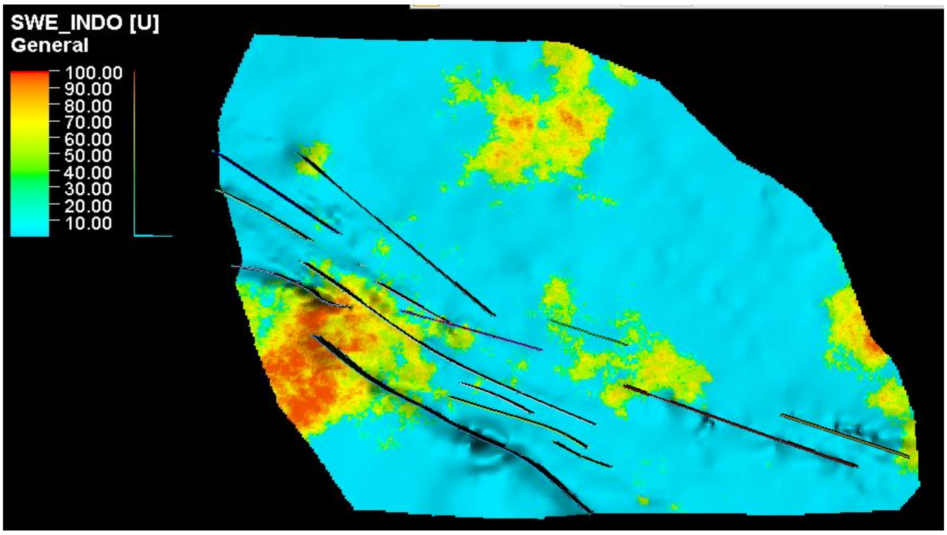


Fig. 24. 3D Water Saturation Distribution Modeling of Khasib Formation

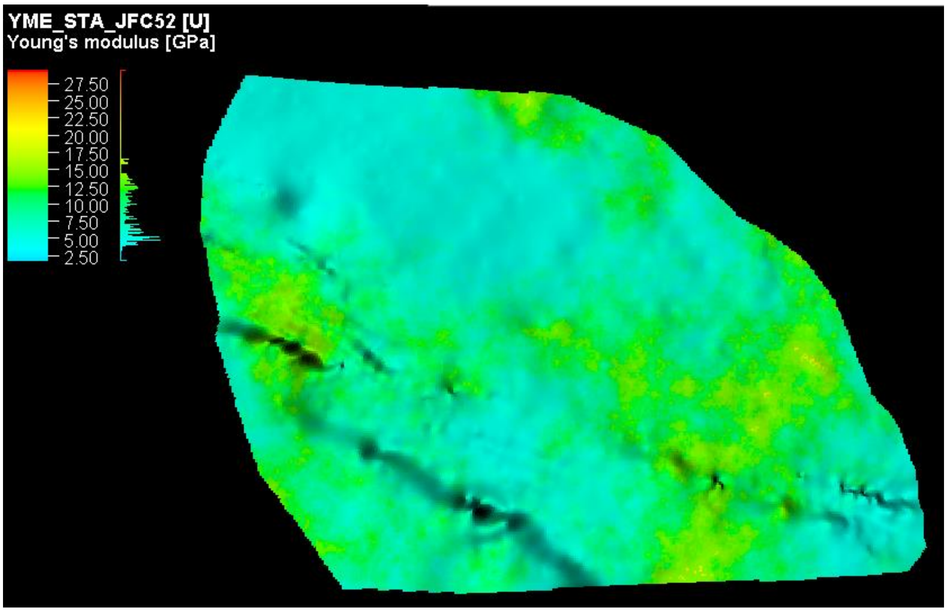


Fig. 25. 3D Young Modulus Distribution Modeling of Khasib Formation

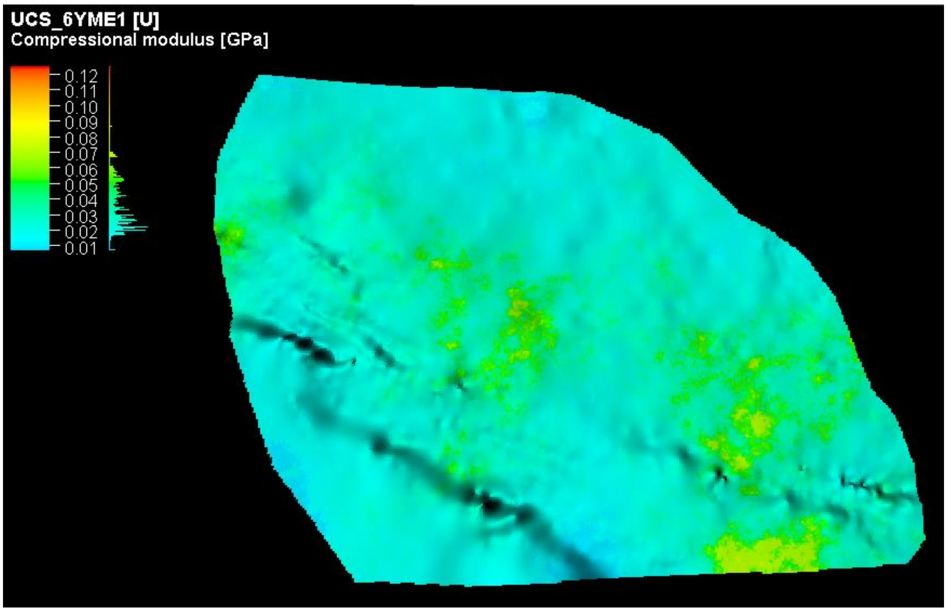


Fig. 26. 3D UCS Distribution Modeling of Khasib Formation

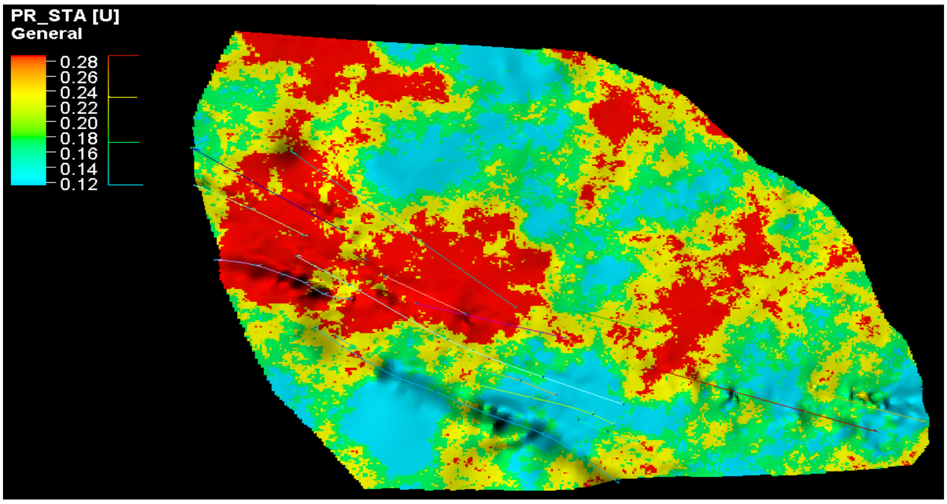


Fig. 27. 3D Poisson's Ratio Distribution Modeling of Khasib Formations

6- Suitable layer selection and perfect well location

Many conditions should be available for accurate selection of the candidate layer selected for conducting hydraulic fracturing operations. The suitable layer selected for the fracturing job is characterized by; low in-situ stress and therefore low fracture gradient, low Young's modulus for the hydro-fracture zone and high Young modulus for barriers, high-stress contrast between hydro-fracture zone and barrier, the high difference between the minimum and maximum horizontal stress, low UCS to make fracturing operation easier and low Poisson's and high porosity, low permeability, and low water saturation.

In the current study to select a suitable layer to create a fracture in each well for the Saadi, Tanuma, and Khasib formations, the key was to use 3-D MEM maps. These maps provide many mechanical properties such as Young’s modulus, Poisson’s ratio, and unconfined compressive strength which must be at low values. Studying well A, and taking into consideration Saadi formation the fracture can be created at 2179 m depth due to the obtained lowest value of YME, PR, and UCS which are 0.735 Mpsi, 0.178, and 3118 psi respectively On the other hand, the candidate depth at Tanuma formation is 2328 m due to the lowest value of YME, PR and UCS which are 0.68 Mpsi, 0.19 and 2923 psi respectively, for Khasib formation at a depth 2475 m where the lowest value is YME, PR and UCS (0.66 Mpsi, 0.17 and 2815). All the candidate depths of the other wells are shown in Table 3.

The selection of perfect well location is adopted in the current study based on the results of both the 3D- MEM maps and the 3-D petrophysical properties maps as shown in Fig. 10 through Fig. 27. The basics of well perfect location choice depending on the best petrophysical properties such as high porosity, low permeability and low water saturation, and low geomechanical properties such as YME, PR and UCS. According to 3-D maps analysis of Saadi formation, it seems that this formation within its three layers has the best petrophysical properties as shown in Fig. 10 to Fig. 12. These properties include a good porosity estimation range from 19 to 24% as shown in Fig.10, and a low permeability range from 0.01 to 18 md as shown in Fig. 11 as well as low water saturation Sw values as shown in Fig. 12. According to these petrophysical properties distribution, the selected well location in Saadi formation can be given at the suggested coordinates of X=463034.86m and Y=3688636.63m. while based on 3-D MEM results of Saadi formation as mentioned in Fig. 13 to Fig. 15. For example, for well A, Saadi formation can create fracture at 2179 m depth due to the obtained lowest value of YME (as shown in Fig. 13), low values of PR (as shown in Fig. 14) and low UCS which are 0.735 Mpsi, 0.178 and 3118 psi respectively (as shown in Fig. 15). On the other hands, when Tanuma formation is under consideration, the best petrophysical properties distribution appear at nearly right direction of the anticline crest of the reservoir as illustrated in Fig. 16 to Fig. 18. The estimated petrophysical properties are good by denoting to high porosity values range from 34 to 37 % (as shown in Fig. 16). and low permeability values range from 0.01 to 20 md (as shown in Fig. 17), and regarding low water saturation Sw values (as shown in Fig. 18). while mechanical properties estimation shows that YME (as shown in Fig. 19), PR (as shown in Fig. 21), and UCS (as shown in Fig. 20) were low values as illustrated in Table 3; accordingly, we can select the well location in the Tanuma formation based on these coordinates (X=470802.96m, Y=3683582.07m). For Khasib formation, find the best distribution of properties concentrated in the center of the crest as shown in Fig. 22 to Fig. 24. While based on 3-D MEM of this formation the lowest value YME (as shown in Fig. 25), PR (as shown in Fig. 26) and UCS as shown in Fig. 27 (0.66 Mpsi, 0.17 and 2815). All the candidate depths of the other wells Accordingly the suggested well location can be given at these coordinates (X=467624019, Y=3681267.52).

Table 3. The choice of Optimum Layer in Each Formation Depends on Geomechanical Properties

Formation	Depth(m)	Young’s modulus (Mpsi)	Poisson’s ratio	UCS (psi)
Well B				
Saadi	2238	0.87	0.28	3706
Tanuma	2422	0.64	0.287	2722
Khasib	2564	0.66	0.288	2812
Well C				
Saadi	2230	1.08	0.233	4599
Tanuma	2360	0.85	0.232	3617
Khasib	2473	0.97	0.231	4137
Well D				
Saadi	2230	0.92	0.116	3918
Tanuma	2344	0.52	0.117	2523

7- Results and discussion

The mechanical earth model must be utilized to predict wellbore stresses and the distribution of geomechanical and petrophysical properties before hydraulic fracturing design and well-site selection. After obtaining the MEM results for the studied four wells as shown in Fig. 5 to Fig. 8, a range of obtained Young’s modulus can be observed, these values are illustrated in Table 4. A high Young’s modulus value indicates that the layers are compact cemented rocks with low porosity and permeability. In contrast, the interval between the higher rocks of the Saadi, Tanuma, and Khasib formations is less solid rocks because these rocks are porous rocks (see Fig. 5 to Fig. 8). Close looking at the distribution map of Young's modulus, it is clear that it recorded high values concentrated in the crest of the formations while recording low values in other parts of the formation. This indicated that the hardness of the rocks is weak in the reservoir except for the crest. In these regions, the recorded porosity and low permeability were also of high value. On the other hand, Poisson's ratio describes the elastic behavior of rocks as shown in Fig. 5 to Fig. 8, the value of Poisson's ratio shown in Table 4 is subject to change due to its close values. In fact, Poisson's ratio is affected by various parameters including rock hardness and rock properties. Unconfined compressive strength (UCS), is one of the main parameters in reservoir geomechanics and represents the strength of the rocks or the rock withstanding the applied stress. Fig. 14, Fig. 20, and Fig. 26 illustrate the 3D distribution of UCS of studied formations. The results showed a higher UCS in some areas The reason is similar to that reason in interpreting the higher values of Young's modulus and Poisson's ratio [13].

The SEM image provides a structural explanation of the behavior of the sample. Several samples show a normal trend in the permeability-strain relationship in the Tanuma/Khasib reservoir. The layer shows low sensitivity of these core samples to stress as shown in Fig. 2 to Fig. 4 describe the SEM and TS testing.

The high porosity of rocks can affect the resulting value of Poisson's ratio due to the presence of tortuous pores partially filled with bright calcite in the studied core samples. The results of Fig. 5 to Fig. 8 also showed that the friction angle for the reservoir under study, as shown in Table 5, falls within the range of carbonate reservoirs.

Table 4. Rock Mechanical Properties Used in The Model

		Well name			
Parameters	**Reservoir**	**A**	**B**	**C**	**D**
Thickness (m)	Saadi	146	160	122	115
	Tanuma	116	137	110	102
	Khasib	125	155	114	113
Young's modulus (Mpsi)	Saadi	0.91-3.21	0.89-2.19	1.16-2.71	0.93-2.38
	Tanuma	0.82-4.10	0.61-9.94	0.98-3.71	0.62-2.91
	Khasib	0.76-6.41	0.72-2.21	0.92-2.71	0.72-3.81
UCS (Mpsi)	Saadi	2934-10765	3958-9373	4550-8310	3939-8717
	Tanuma	2861-11449	2740-6487	3781-13217	2523-12312
	Khasib	2957-21095	2766-10150	3877-7624	3085-20054
Poisson ratio	Saadi	0.17-0.18	0.286-0.29	0.23-0.235	0.114-0.117
	Tanuma	0.18-0.24	0.285-0.285	0.231-0.233	0.115-0.118
	Khasib	0.16-0.2	0.284-0.29	0.233-0.236	0.112-0.12

Table 5. Cohesion and Friction Angle Used in The Model

Well name	Cohesion(psi)	Friction angle(deg)
A	724-6376	30-38
B	906-2077	34-39
C	1264	29-37
D	1722-3931	34-39

8- Conclusions

Based on the constructed 1-D MEM and the obtained results, the present study of a suitable layer selection for conducting a hydraulic fracturing job has the following highlights:

- From 1-D MEM, it was concluded that Young modulus (E) and unconfined compressive strength (UCS) are the most important factors among geomechanical parameters that affected perfect layer selection.
- Among the studies on rock mechanical properties, it is also noted that horizontal stresses are a crucial parameter for the best layer selection.
- The layer appears to be lowly sensitive to stress; this is clear from analyzing the core samples using the SEM and TS tests.
- High rock porosity can affect the resulted value of the Poisson ratio caused by a vuggy pore partially filled with sparry calcite in the studied core samples, as described in the SEM and TS tests.

Nomenclature

σ = Normal stress Psi
ε =Strain Unitless
τ =Shear stress Psi
V =Vertical stress Psi
σH= Maximum horizontal stress Psi
σh =Minimum horizontal stress Psi
Ppg =Pore pressure gradient Psi/ft
Pp =Pore pressure Psi
UCS =Unconfined compressive strength Psi
φ FANG =Internal friction angle degree
To TSTR= Tensile strength Psi
Co So= Cohesive strength Psi
ν PR =Poisson's ratio Unitless
E YME =Young's modulus Mpsi
$Edyn$ =Dynamic Young's modulus Mpsi
G =Shear modulus Mpsi
K= Bulk modulus Mpsi
Cb =Bulk compressibility 1/Mpsi
ρb =Bulk density gm/cc
Vp =Compressional wave velocity Km/s
Vs =Shear wave velocity Km/s

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تحديد منطقة الطاقة الانتاجية الاعلى للتشققات الهيدروليكية في حقل شرقي بغداد النفطي

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الخلاصة

المكمن الذي يتمتع بقدرة تخزينية عالية وقدرة منخفضة على الإنتاج، فإن المشكلة الخطيرة تتمثل في الانخفاض الحاد في إنتاجية البئر المسجلة خلال فترة قصيرة. أحد الحلول لهذه المشكلة هو إنشاء كسور هيدروليكية تعمل على زيادة نفاذية التكوين والحفاظ على إنتاجه بمعدلات عالية لفترة كافية. إن معرفة السلوك الجيوميكانيكي لهذه الخزانات لها تأثير حاسم على نجاح عملية التكسير الهيدروليكي. في هذه الدراسة، سيتم استخدام حجم واتجاه الإجهاد الصخري، ومرونة الصخور، وقوة الصخور حتى بدء التكسير، وكل هذه العوامل بالإضافة إلى الخواص البتروفيزيائية لتحديد ما إذا كانت عملية التكسير الهيدروليكي يمكن أن تكون ناجحة أم لا. تعتبر النمذجة المتكاملة للمكمن المدروس خطوة أساسية تتضمن التقييم الجيوميكانيكي أحادي الأبعاد للعديد من التكوينات من أجل اختيار الطبقة المثالية لإنشاء الكسر الهيدروليكي. تم عرض الخواص الجيوميكانيكية وتوزيع الخواص البتروفيزيائية ثلاثية الأبعاد من أجل الاختيار الأمثل لهذه الخواص. يتم دعم التقييم الجيوميكانيكي للمكامن قيد الدراسة من خلال التقييم التجريبي للعينات الأساسية بما في ذلك اختبار حيود الأشعة السينية (EDS) وصورة المجهر الإلكتروني الماسح (SEM) وصورة المقطع الرقيق (TS) .أظهرت النتائج أن الانخفاض في الخواص الجيوميكانيكية المحسوبة من حيث معامل بواسون و معامل الاستطالة و قوة الانضغاط مناسب لاختيار الطبقة المرشحة. ومن بين دراسات الخواص الميكانيكية للصخور، لوحظ أيضًا أن قوة الضغط الغير محصور هو عامل حاسم لاختيار أفضل طبقة. تم توضيح الأعماق المناسبة لوظائف التكسير بالتفصيل في هذه الدراسة باستخدام بيانات مختصرة تم جمعها من أربعة آبار.

الكلمات الدالة : نموذج الأرض الميكانيكي، التكسير الهيدروليكي، المجهر الإلكتروني الماسح، المقطع الرقيق و افضل طبقة.