Iraqi Journal of Oil & Gas Research, Vol. 3, No. 1 (2023)

Iraqi Journal of Oil & Gas Research

Journal homepage: https://ijogr.uotechnology.edu.iq

Applying Facies Characterization to Build 3D Rock-Type Model for Khasib Formation, Amara Oil Field

***Alyaa M. Ali* [1,*] *and Ayad A. Alhaleem A. Alrazzaq* [2]**

[1] Oil and Gas Engineering Department, University of Technology-Iraq, Baghdad, Iraq.
[2] Petroleum Engineering Department, College of Engineering, University of Baghdad, Baghdad, Iraq

Article information

Article history:
Received: March, 04, 2023
Accepted: April, 02, 2023
Available online: April, 08, 2023

Keywords:
Reservoir Characterization,
Rock-Type Modeling,
Khasib Formation,
Flow Zone Indicator,
Cluster Analysis

Corresponding Author:
Alyaa Mahmood Ali
150039@uotechnology.edu.iq

Abstract

An accurate three-dimensional geological model is an essential step to represent the spatial variation in the petrophysical properties and how the fluid flows within the hydrocarbon-bearing formation. Building a rock-type (facies) model is critical in the process of constructing the geological model.
The rock-type (facies) model utilizes the facies obtained from the different characterization methods to represent the structure and the geology of the studied reservoir. Therefore, the importance of building a 3D rock-type model is to distribute the petrophysical properties depending on the rock facies in order to reflect the actual distribution and achieve a realistic model.
Khasib formation in Amara oil field is mainly composed of limestone and exhibits a high degree of heterogeneities in its petrophysical and geological features, showing a complicated porosity-permeability relationship. Hence, the formation should be characterized by rock type (facies) with specific property relationships and use these facies to build an accurate rock-type model to represent the geological rock modeling for this carbonate formation.
The Rock-Type model for Khasib formation has been constructed using the facies obtained from flow zone indicator and cluster analysis characterization methods, these facies were distributed with the PETREL software by applying the sequential indicator simulation (SIS) algorithm.
The 3D Rock- type model establishes that a different rock type characterized each unit within Khasib formation; the reservoir units (KH11, KH12, and KH2) were characterized by the presence of RT-1, RT-2, and RT-3, which represent the best, good, and intermediate reservoir quality rocks, respectively. The best rock type RT-1 with the best reservoir petrophysical properties was only noticed in unit KH2. The non-reservoir units (Khasib, Base KH11, Base KH12, and Base KH2) were characterized by RT-4 and RT-5, which reflect the bad rock quality with non-reservoir properties.

DOI: http://doi.org/10.55699/ijogr.2023.0301.1040 , Oil and Gas Engineering Department, University of Technology-Iraq

1. Introduction

Petroleum engineering depends strongly on Knowledge of accurate reservoir characteristics for tasks like estimating the hydrocarbon reserves, calculating well inflow efficiency, and reservoir modeling. [1]

The key step in building a realistic 3D model is to have an accurate reservoir characterization because it provides critical information on the three-dimensional distribution and realization of the reservoir heterogeneity and petrophysical properties [2]. Therefore, reservoir characterization aims to produce a geological model that honors the available data and can be used to predict the distribution of porosity, permeability, and fluids throughout the field [3]. Even though, Characterizing and modeling hydrocarbon-bearing reservoirs is not an easy task because the reservoir properties vary spatially due to reservoir heterogeneities which occur at all scales, from pore scale to major reservoir units [4].

The description of geological rock is referred to as facies (rock-type), which can be categorized based on the geological facies that describe the environment in which it is deposited. A rock type is a group of rocks that were deposited under comparable circumstances, went through comparable diagenetic processes, and as a result, had a specific porosity-permeability relationship and other characteristics. [5]

In this work, PETREL Software was the tool for building the 3D rock-type model for Khasib formation utilizing the well-log interpretation data, and the electrofacies produced with Techlog Software for the 18 well within the field. To construct a three-dimensional rock-type model for Khasib reservoir in Amara oilfield, we need to distribute the facies obtained from the cluster Analysis technique and the FZI method through the formation to capture and anticipate the spatial variation of the rock faciesThis rock-type model is crucial for comprehending the stratigraphy and structure of the reservoir under study, and the distribution of the petrophysical characteristics of this formation should be based on it.

2. Description of Studied Area

The field is Amara oilfield, located in southeastern Iraq in Missan governorate, about 10 km southwest of Amara. There are various oil fields surrounding Amara field, Amara field is far away from Al-Rafedain field about 25 kilometers in the east, Al-Kumait field about 30 kilometers in the southwest, Halfaya field about 10 kilometers in the northwest, and Noor field about 15 kilometers to the southwest [6] as shown in Fig.1.

The structure of the field comprises a single anticline semi-symmetrical, with the axis trending North West – South East elongated and with dimensions of 18km in length and 4.5km in width. Amara Field is operated by Missan Oil Company (MOC) and currently has 18 wells. The field was discovered in 1957 and put into production in 2000. Amara field is now in the development phase and is producing hydrocarbons from the Mishrif formation (Middle Cretaceous) as the main target, with late Cretaceous Khasib and the Lower Cretaceous Nahr Umr as secondary targets [7].

The reservoir under study is the Khasib carbonate formation, which is considered one of the significant petroleum reserves in the south of Iraq. The formation thickness is ranging from 35 to 56m in Basra fields [8] and increases towards the northeast to range from 60 to 120 m in middle Iraq oil fields [9], while Khasib formation in Amara field is roughly between 75 and 80 meters thick and its depth is about 2790 m at the top of the formation, measured from sea level at well Am-06.

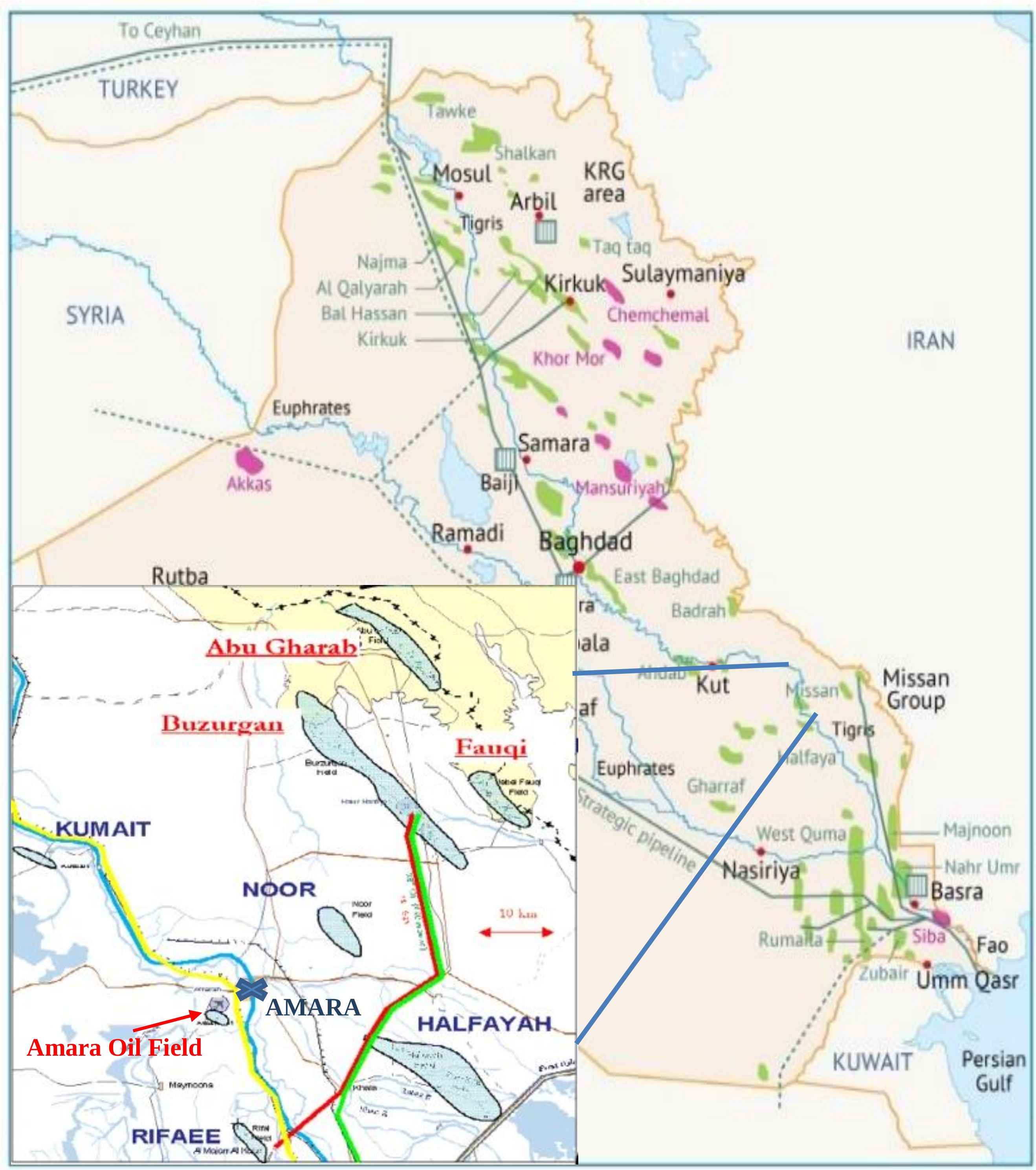

Fig. 1: The location and the structural map of Amara Oil Filed.

3. Work Procedure

Collecting the data required to build the geological model for khasib formation are the wellhead data, well top data, contour map, and well log data, including porosity, water saturation, and the electrosacies from clustering. Khasib formation was subdivided into seven zones to represent the formation in the 3D geological model as follows:

- The reservoir units are represented as KH11, KH12, and KH2.
- The non-reservoir units are represented as Khasib, Base KH11, Base KH12, and Base KH2.

Building the rock-type model by entering the data into PETREL software and starting to construct the structural model. Furthermore, build the 3D model by dividing the formation into grids and layers. Finally, the rock-type (facies) model was prepared by distributing the face through the formation.

3.1. Structural model

The structural modeling for Khasib reservoir has been built using the well top data and the structural contour map for the top of Khasib reservoir. Eight structural maps were constructed to represent the top surface for each unit in Khasib reservoir.

3.2. Make simple grid

The 2D grid has been made with a 100*100 grid cell increment to utilize 167 grids in the X direction and 64 grids in the Y direction. The results for the 2D grid can be represented by the three skeleton grids.

3.3. Layering

The aim of layering is to subdivide each zone into several layers in the vertical direction to make the property distribution more accurate, especially in the reservoir units.

3.4. Scale up well logs

Scale-up is the process where the well logs are blocked into the grid cell, seeking to define a single value for each property in each cell to avoid the problem of having a number of cells that is significantly greater than the density of well logs [10]. Several averaging algorithms are available for scaling up the log data, including arithmetic, harmonic, and geometric. The (most of) averaging algorithms have been used for scaling up the rock types.

3.5. Rock-type modeling

Rock-type modeling is an important step for understanding the lithology and the property distribution throughout the reservoir and thus building more accurate models. Rock-type modeling is utilized to fill the model grids with distinct rock type values to characterize the reservoir's lithology.

4. Results and Discussion

Rock type model for Khasib formation has been constructed using the facies interpretation obtained from the electrofacies of the cluster analysis and by incorporating the cluster analysis facies with the HFUs of the FZI method, five rock types were obtained to characterize the different units in Khasib formation are represented in Table (2). [11]

Table 2: Rock types obtained from cluster Analysis and FZI method.

Rock Type	FZI HFUs	Cluster Electro-Facies	Vsh Avg. v/v	PHIE Avg. v/v	Sw Avg. v/v	K md
RT-1	HFU 5	EF 5	0.003	0.24	0.22	34-773
RT-2	HFU 4	EF 3	0.1	0.17	0.3	40-104
RT -3	HFU 3	EF 1	0.15	0.11	0.4	0.32-60
RT -4	HFU 2	EF 4	0.02	0.14	0.5	0.01-7
RT -5	HFU 1	EF 2	0.04	0.05	0.92	0.01-0.5

These rock types can be described as follows:

- Rock Type-1: this rock type represents the best reservoir rock type for khasib formation and defines as RT-1 (best).
- Rock Type -2: this rock type represents good reservoir rock quality for Khasib reservoir and defines as RT-2 (good).
- Rock Type -3: this rock type represents the intermediate reservoir rock quality and defines as RT-3 (intermediate).
- Rock Type -4: this rock type represents the poor reservoir rock type and defines as RT-4 (poor).
- Rock Type -5: this rock type represents very bad rock quality and corresponds to the non-reservoir units and defines as RT-5 (non-reservoir).

The Rock type modeling for Khasib formation has been applied for each zone through the use of the sequential indicator simulation (SIS) algorithm and the existence of every rock type in each zone is established in Fig. (2) which represents the rock type distribution for the different zones of Khasib formation. The two cross-sections in Fig. (3) and Fig. (4) show the spatial variation in rock types throughout the field. The 3D rock-type model for the KH11 reservoir zone of Khasib formation is demonstrated through Fig. (5) to Fig (11).

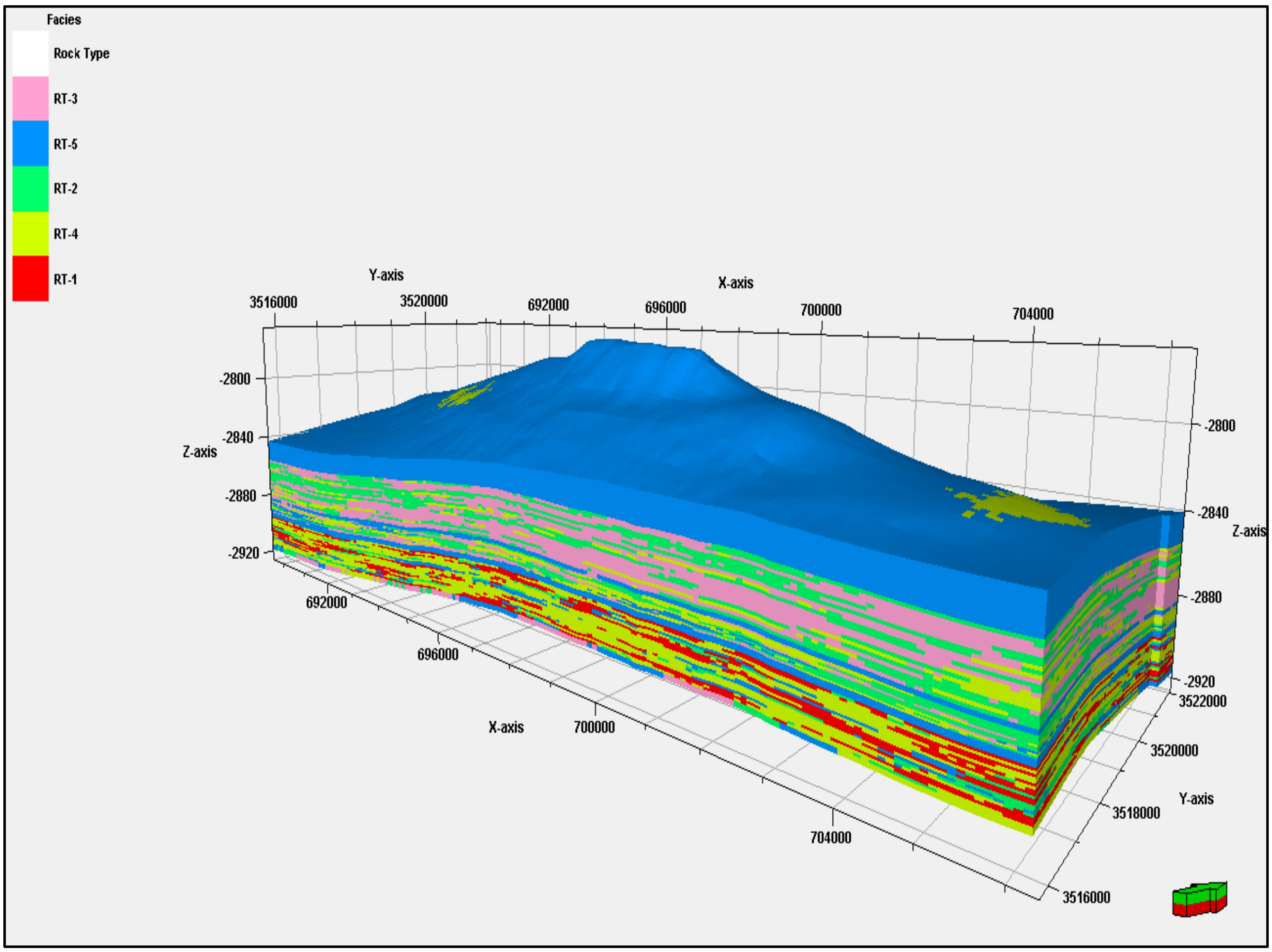

Fig. 2: Rock types model for Khasib formation.

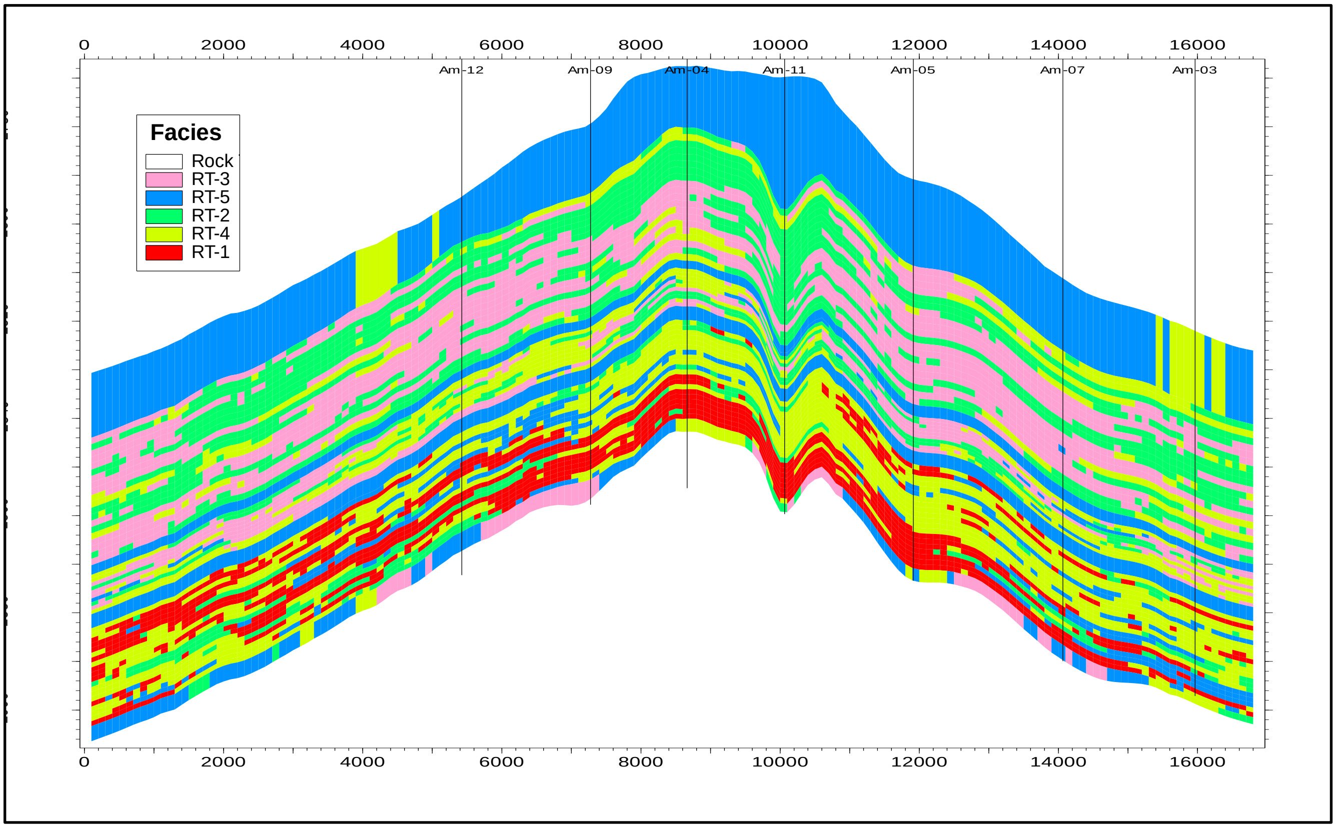

Fig. 3: East-west cross-section for rock type model of Khasib formation.

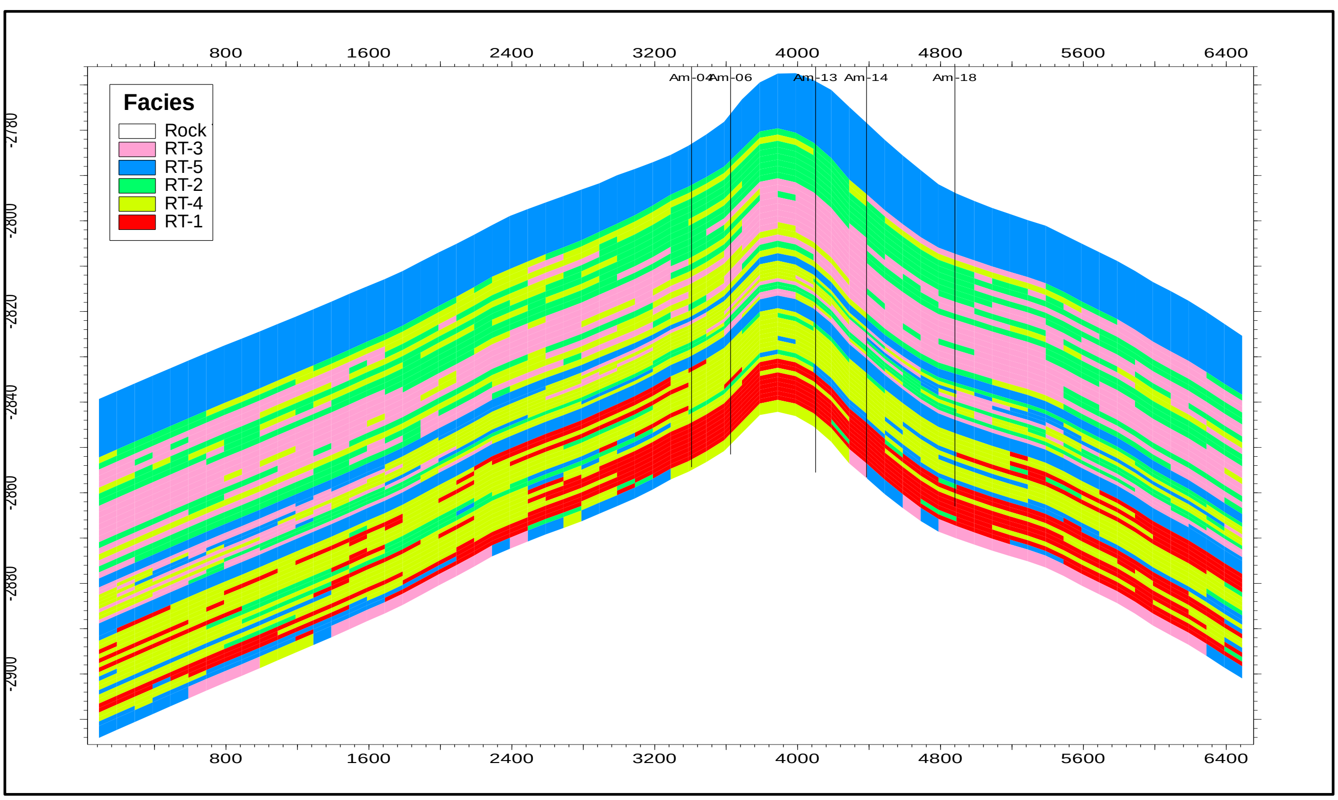

Fig. 4: North-south cross-section of rock type model for Khasib formation.

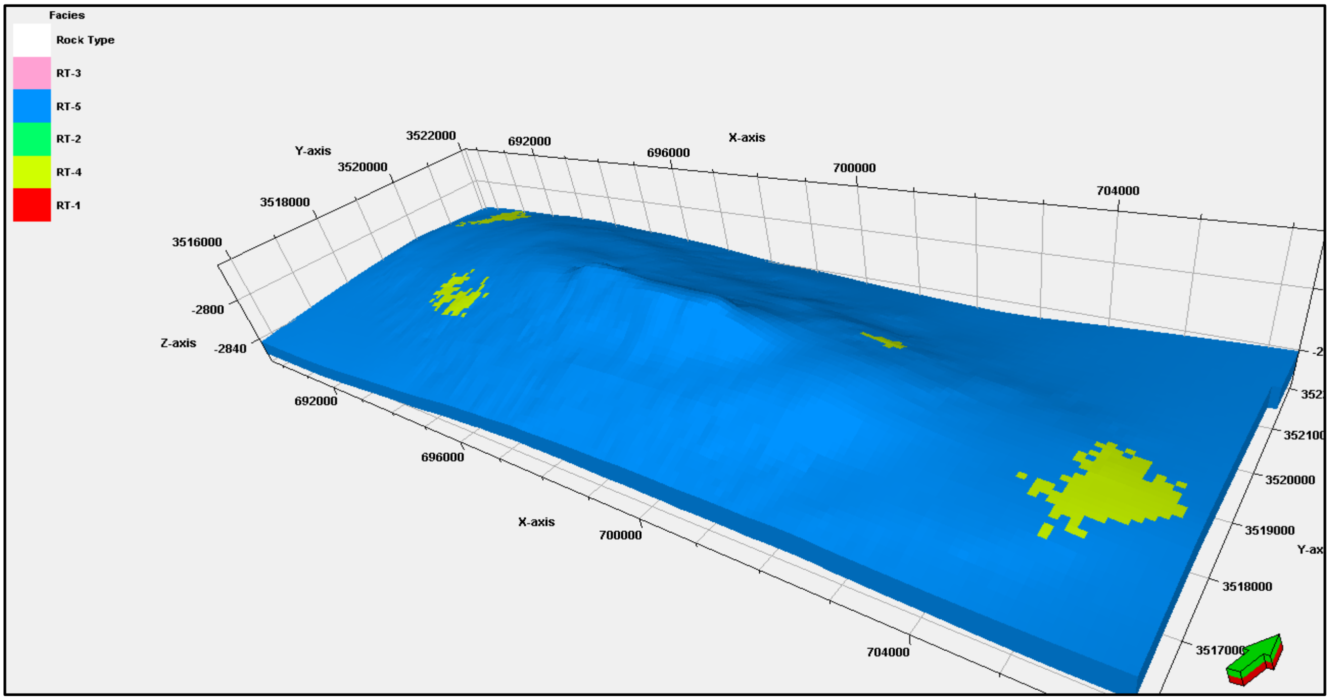

Fig. 5: Rock-type model for Khasib zone.

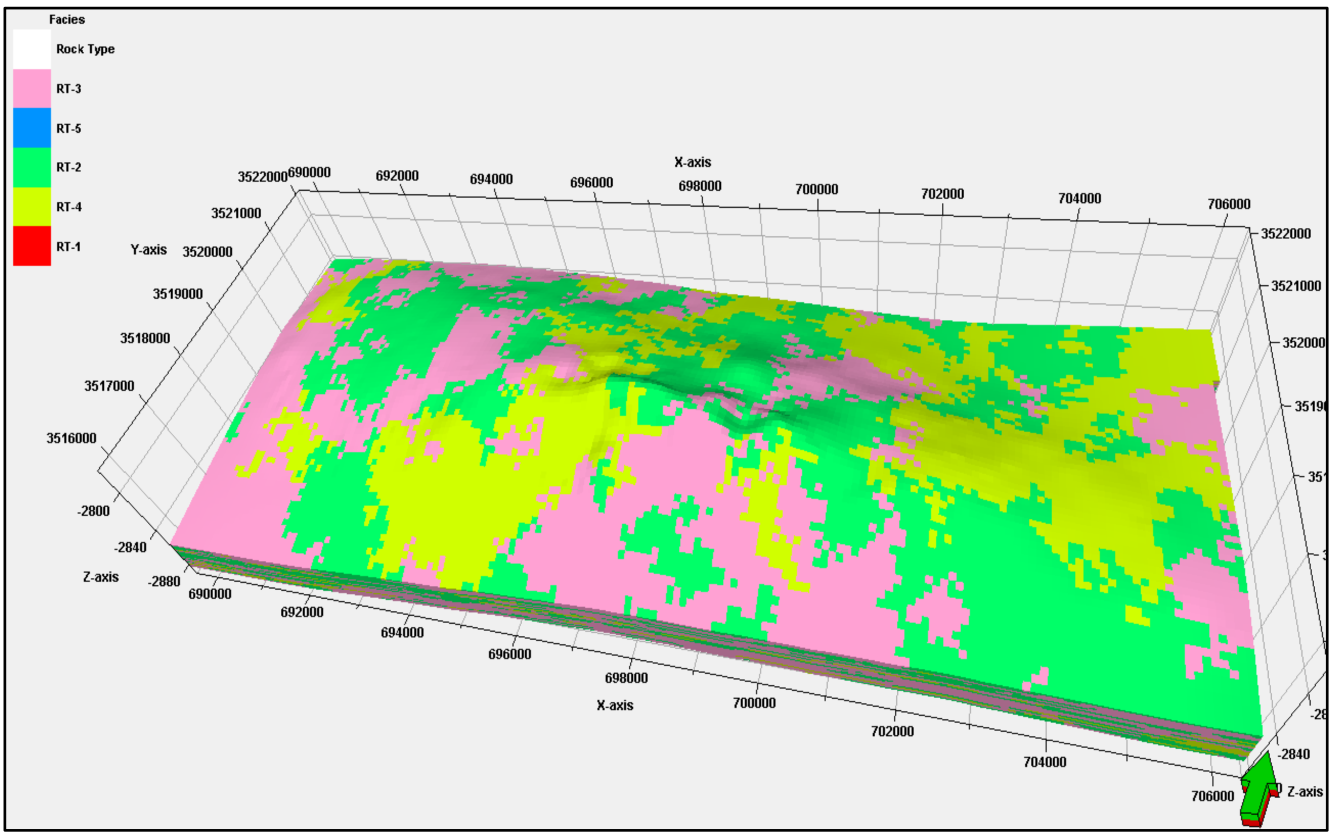

Fig. 6: Rock type distribution for KH11 zone.

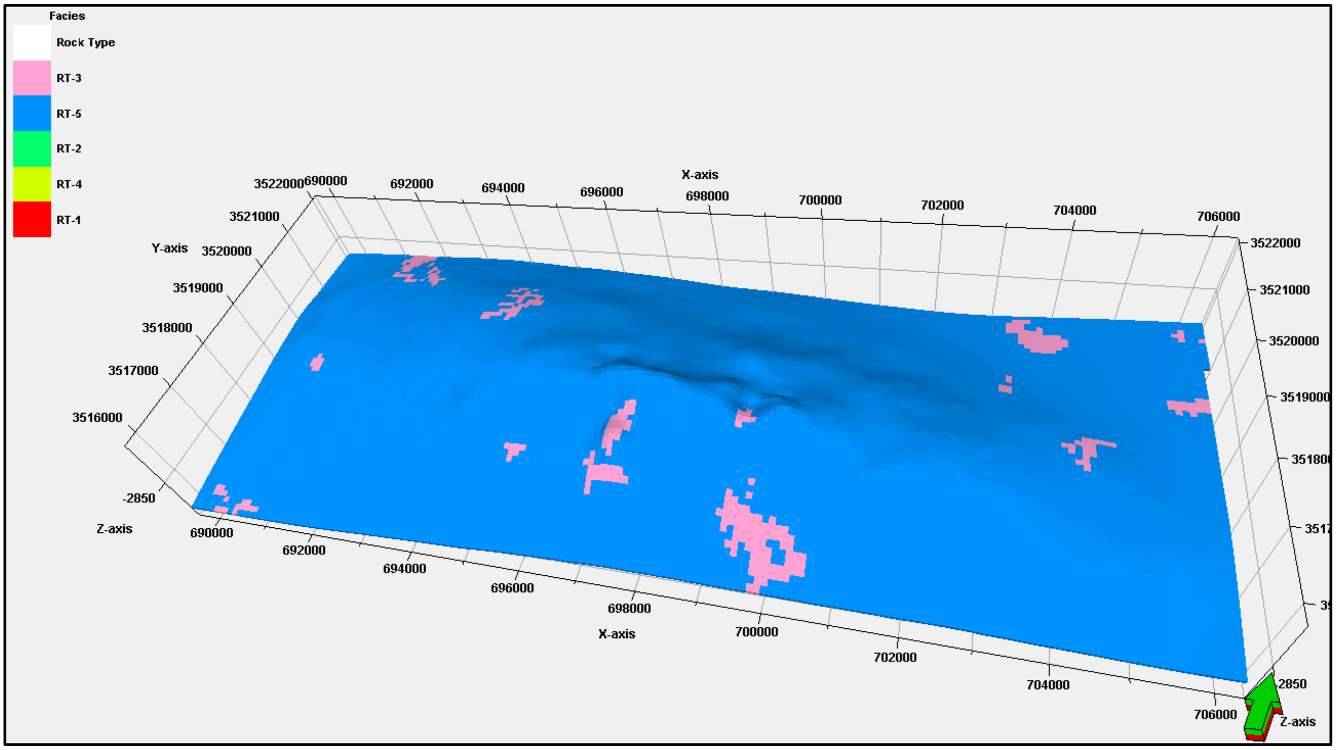

Fig. 7: Rock-type model for Base KH11 zone.

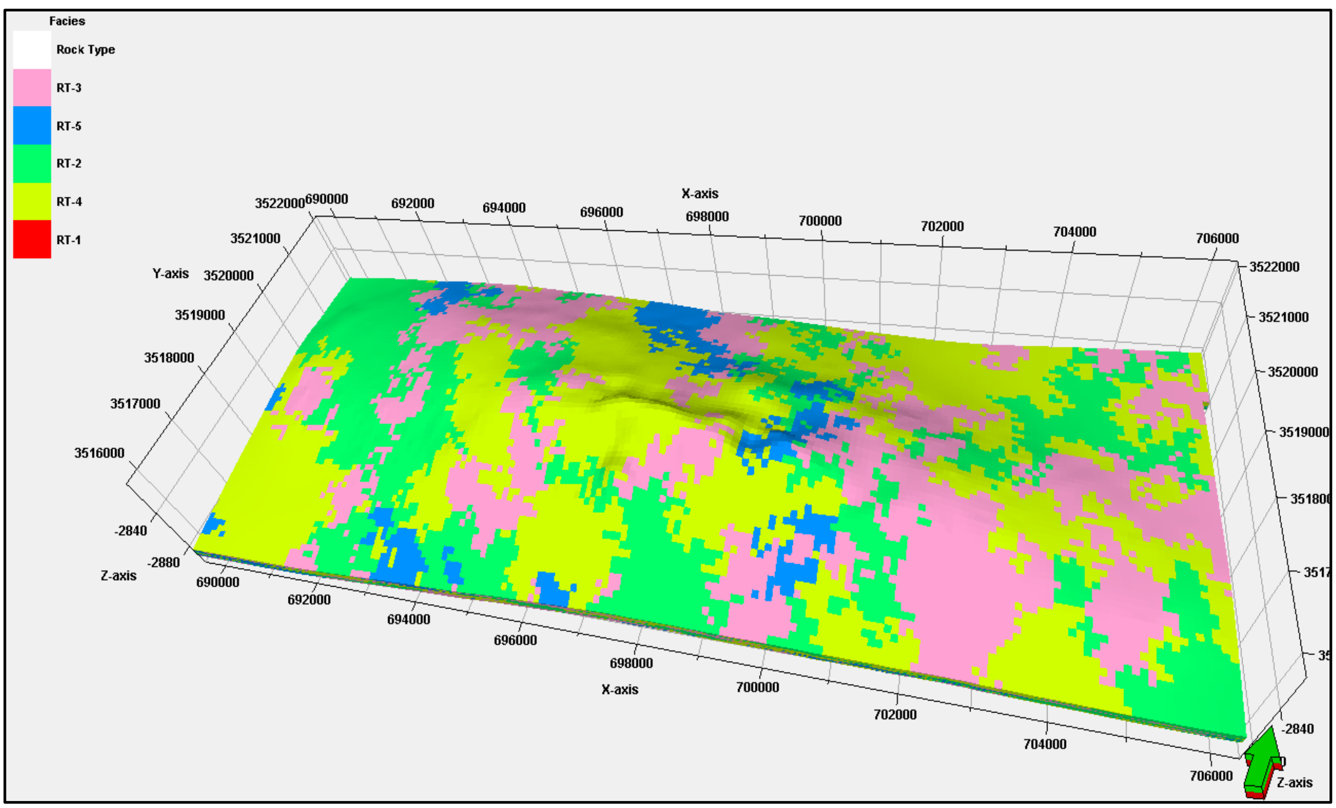

Fig. 8: Rock-type for KH12 zone

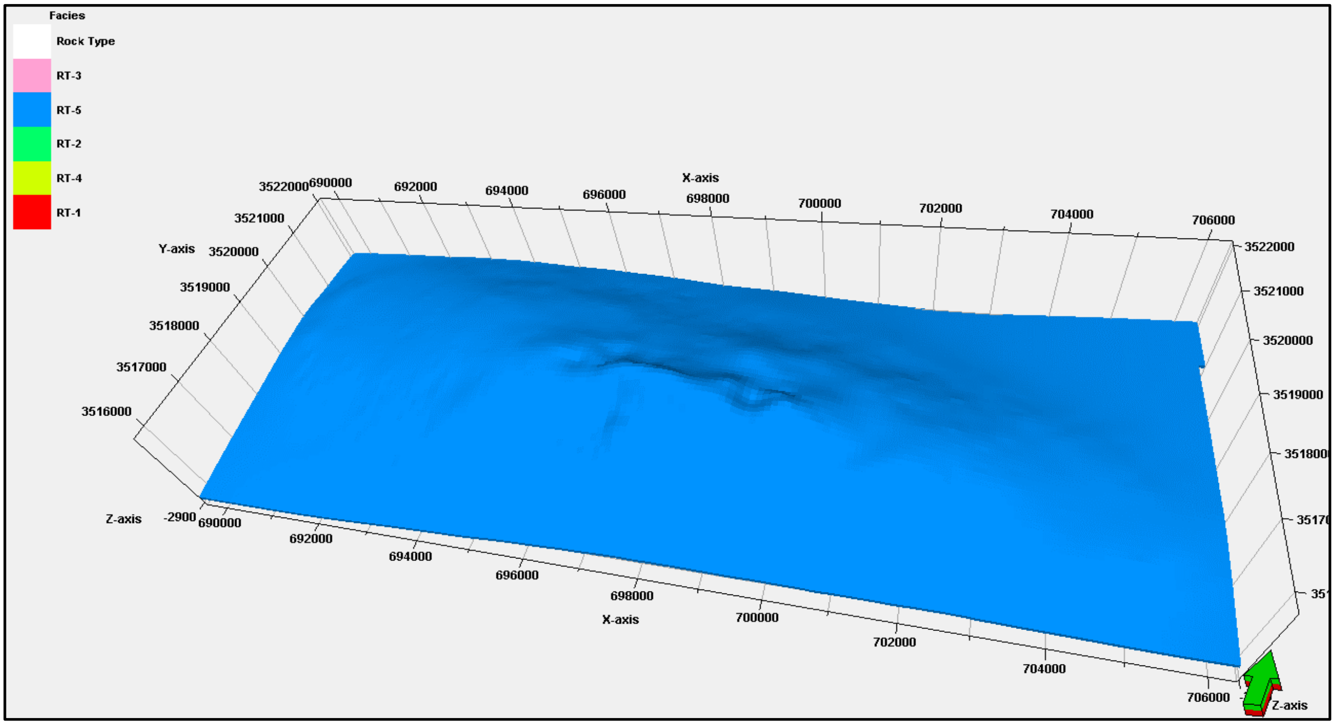

Fig. 9: Rock-type model for Base KH12 zone.

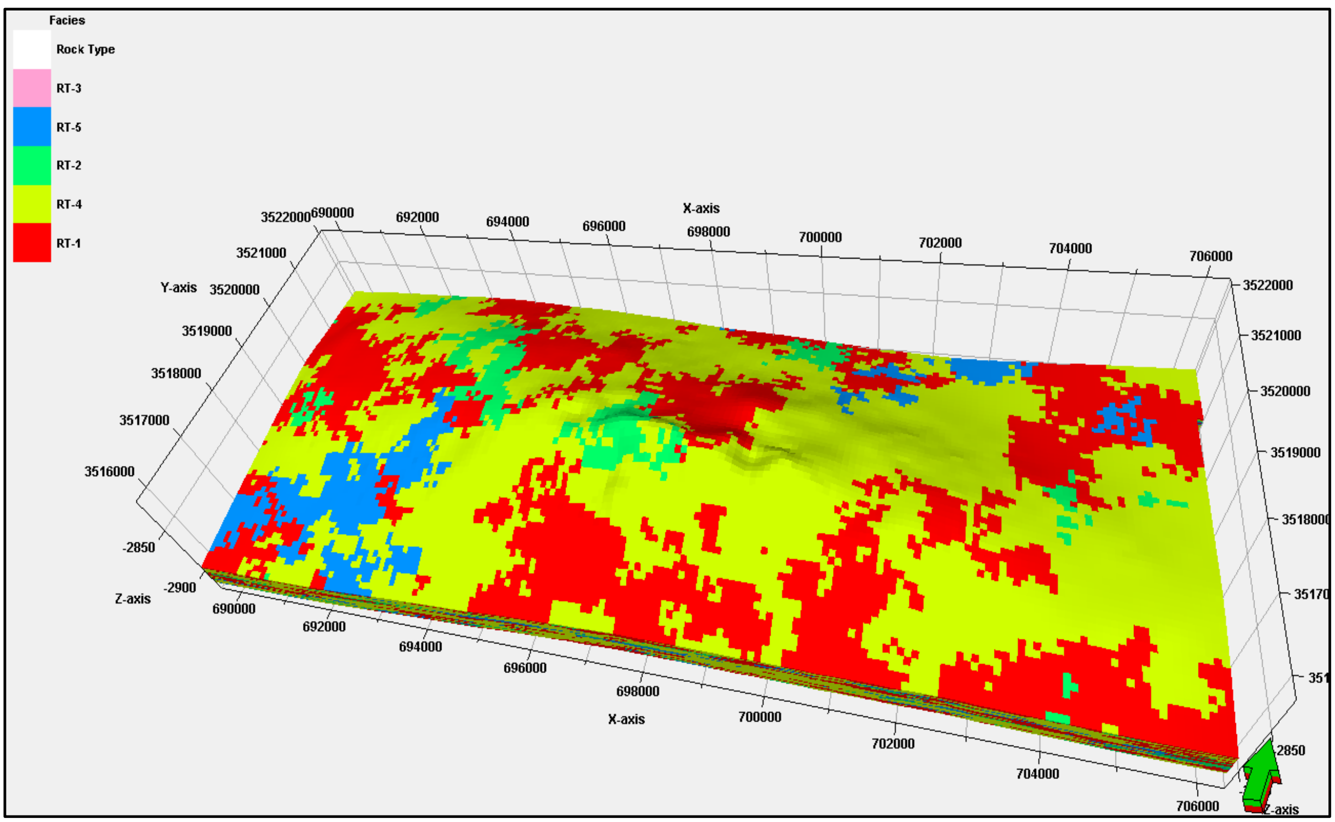

Fig. 10: Rock-type model for KH2 zone.

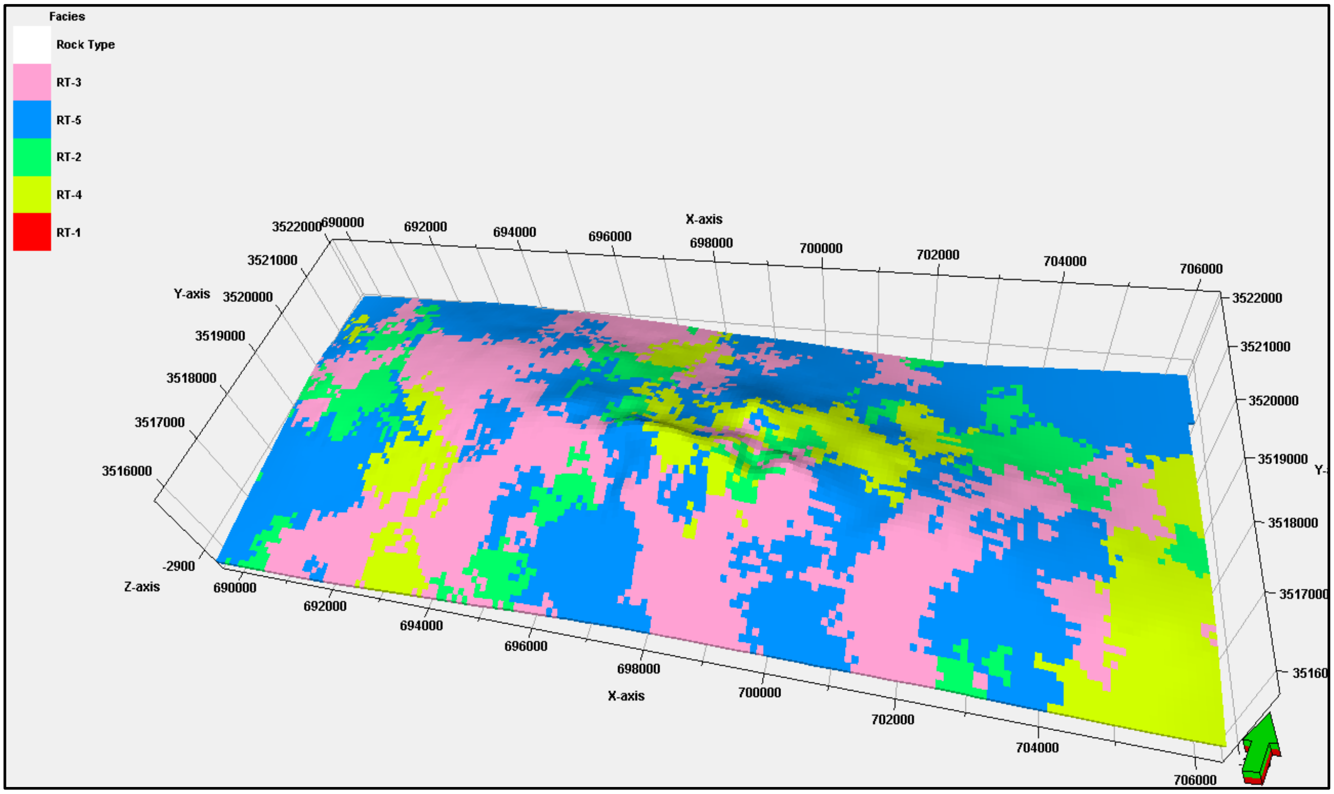

Fig. 11: Rock-type model for Base KH2 zone

From these figures, the following observations for the rock type distribution of each zone can be established.

- Khasib: This zone is mainly composed of RT-5, which represents the non-reservoir rock.
- KH11: This zone is mainly composed of RT-2 and RT-3, which correspond to the good and intermediate reservoir rock types with the slight appearance of RT-4.
- Base KH11: This zone is mainly composed of RT-5, which represents the non-reservoir rock.
- KH12: This zone is composed of RT-2 and RT-3, which correspond to the good and intermediate reservoir rock and are interbedded with the poor reservoir rock RT-4.
- Base KH12: This zone is mainly composed of RT-5, which represents the non-reservoir rock.
- KH2: This zone is characterized by containing the RT-1, which represents the best reservoir rock type. Furthermore, the RT-4 with the poor reservoir rock was noticeable in this reservoir zone.
- Base KH2: This non-reservoir zone is mainly composed of RT-5, interbedded with RT-4. Even though, the RT-3 was noticeable in this non-reservoir zone. This zone is considered the bottom of Khasib formation and separates it from Mishrif formation.

5. Conclusions

- The rock type model for Khasib formation has been built by incorporating two reservoir characterizing methods: the five RTs obtained from cluster analysis and the five HFUs from the FZI method, to identify five rock types that characterize the formation.
- The five rock-type of Khasib formation are: RT-1 represents the best rock type (PHI avg. = 24%, Sw avg. =22%, and K= 34-773 md), RT-2 represents the good rock type (PHI avg. =17%, Sw avg. =30%, K= 40-104md), RT-3 represents the intermediate rock type properties (PHI avg. =11%, Sw avg. =40%, and K= 0.32-60md), RT-4 represents the poor rock type in the reservoir (PHI avg. =14%, Sw avg.= 50%, and K= 0.01-7 md), and RT-5 represents the non-reservoir rock type in Khasib formation (PHI avg.= 5%, Sw avg.= 92%, and K =0.01-0.5md).
- The reservoir units KH11, and KH12 were mainly composed of RT-2 and RT-3 which makes this unit characterized with good to intermediate reservoir properties while the KH2 reservoir unit was the only one recognized by the presence of RT-1 that make this unit characterized with the best reservoir rock properties. For the non-reservoir units (Khasib, Base KH11, Base KH12, and Base KH2) were mainly composed of RT-4 and RT-5 which represent the bad rock properties.

Abbreviations

3D Three Dimensional

FZI Flow Zone Indicator

HFU Hydraulic Flow Unit

RT Rock Type

References

[1] D. S. Mahdi, E. Al-Khdheeawi, D. Al-Bayati, and C. Lagat, “Reservoir fluids model for a middle eastern sandstone reservoir,” *Iraqi Journal of Oil and Gas Research (IJOGR)*, vol. 1, no. 1, pp. 45–58, 2021.

[2] F.J. Lucia, “*Carbonate Reservoir Characterization: An integrated approach*. 2nd ed., Springer, 2007.

[3R.C. Selley and S.A. Sonnenberg, “*Elements of petroleum geology”*. 3rd ed., Amsterdam, Elsevier, 2015.

[4] V. Singh, “Key factors affecting 3D reservoir interpretation and modelling outcomes: Industry perspectives,” *British Journal of Applied Science & Technology*, vol.3, no.3, pp. 376–405, 2013. Available at: https://doi.org/10.9734/bjast/2014/3089.

[5] I. Yuliandri, “Facies (rock type) modeling using inverse static model process from ...” [Online]. Available: https://www.searchanddiscovery.com/documents/2014/41442yuliandri/ndx_yuliandri.pdf. [Accessed: 30-Mar-2023].

[6] A. A. M. qrawi J. C.Goff, A. D. Horbury and F. N. Sadooni, "The Petroleum Geology of Iraq", 1st ed., Scientific Press, pp. 424, 2010.

[7] A. Mohammed, M. Dhaidan, S. Al-Hazaa, S. Farouk and K. Al-Kahtany, "Reservoir characterization of the upper Turonian – lower Coniacian Khasib formation, South Iraq: Implications from electrofacies analysis and a sequence stratigraphic framework", Journal of African Earth Sciences, vol. 186, pp. 104431, 2022. https://doi.org/10.1016/j.jafrearsci.2021.104431

[8] S. Owen and N. Nasr, "The Stratigraphy of the Kuwait-Basrah Area". In: Weeks, R. (Ed.), Habitat of Oil. AAPG Symposium, pp. 1252–1278, 1958.

[9] B. Al-Qayim, "Sequence stratigraphy and reservoir characteristics of the turonian-coniacian the Khasib formation in central Iraq ", Journal of Petroleum Geology, vol. 33, no. 4, pp. 387-403, 2010. https://doi.org/10.1111/j.1747-5457.2010.00486.x

[10]"Petrel Support," *software.slb.com*. [Online]. Available: https://www.nexttraining.net/sitecore/content/software/home/software/Support/Petrel.

[11] A. M. Ali and A. A. Alhaleem, "Reservoir and Rock Type Characterization: Case Study for Khasib Formation, Southern Iraq," Accepted in *Iraqi Journal of Chemical and Petroleum Engineering, 2022*.