Available online at https://ijcpe.edu.iq and www.iasj.net
Iraqi Journal of Chemical and Petroleum Engineering
Vol.19 No.2 (June 2018) 9 – 13
ISSN: 1997-4884

Cluster Analysis Approach to Identify Rock Type in Tertiary Reservoir of Khabaz Oil Field Case Study

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Abstract

Rock type identification is very important task in Reservoir characterization in order to constrict robust reservoir models. There are several approaches have been introduced to define the rock type in reservoirs and each approach should relate the geological and petrophysical properties, such that each rock type is proportional to a unique hydraulic flow unit. A hydraulic flow unit is a reservoir zone that is laterally and vertically has similar flow and bedding characteristics. According to effect of rock type in reservoir performance, many empirical and statistical approaches introduced. In this paper Cluster Analysis technique is used to identify the rock groups in tertiary reservoir for Khabaz oil field by analyses variation of petrophysical properties data that predicted by analysis of well log measurements. In tertiary reservoir four groups identified by cluster analysis technique, were each group was internally similar in petrophysical properties and different from others groups.

Keywords: Rock identification, Khabaz oil field

Accepted on 23/5/2016

1- Introduction

Cluster analysis is a multivariate approaches which aims to distribute a sample of subjects of a set variable measured into a different number of groups where similar subjects are placed in the same group [1]. Well log cluster analysis is process aim to look for similarities and dissimilarities between data points in the multivariate space of logs, in order to distribute them into classes called electrofacies Suzan et al 2010. An electrofacies is a unique set of log responses that characterizes the rocks physical properties and fluids contained in the volume that investigated by the logging tools [2]**.** There are different methods that can be used to make a cluster analysis; these methods can be classified as follows [1]

1.1. Hierarchical Approach

In this approach there are different methods which clusters should be joined at each stage. The main methods are summarized as:

a. **Nearest neighbor method** in this method the distance between two clusters between the two closest members, or neighbors.
b. **Furthest neighbor method** In this case the distance between two clusters is defined to be the maximum distance between members.
c. **Average method** the distance between two clusters is calculated as the average distance between all pairs of subjects in the two clusters.

The distance between two subjects can be measured by Euclidean distance as following [1].

$$dxy = \sqrt{\sum_{j=1}^{j}(xj - yj)^2} \quad (1)$$

1.2. Non-Hierarchical or K-means Clustering Methods

In these methods desired in advance the number of clusters to specify and the best solution is chosen. When large data sets are involved, Non-hierarchical cluster analysis tends to be used it allows subjects to move from one cluster to another so, sometimes preferred because this isn't possible in hierarchical cluster analysis. There are two disadvantages of k-mean cluster analysis first know how many clusters likely to have often difficult and therefore the analysis may have to be repeated several times and second it very sensitive to the choice of initial cluster [1].

The clustering proses based on two stages. Firstly, the well log data is classified into manageable data clusters so that the number of clusters should be enough to cover all the different data ranges that can be detect on the logs

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data .the reasonable number of clusters for most data sets are between 15 to 20 clusters.

The second step based on takes these 15 to 20 clusters and group them into a manageable number of rocks types and reducing the data to 4 to 5 homogenous groups [3].

2- Main Section

Khabaz oil field is one of Iraqi field with multiple pay zones similar to most of the northern Iraqi carbonate oil fields. It's located to North West of Kirkuk city and far away about 12 km from Kirkuk city center [4].

This paper is developed by depending on data from eleven wells was selected for this study. Interactive petrophysics program 3.5 used to apply cluster analysis in order identify rock type for tertiary reservoir in Khabaz field.

Sonic (DT), bulk density (RHOB), water saturation (Sw), and effective porosity (PHIE) and predicted permeability(K) logs for the eleven studied wells, were used as input data for cluster analysis, 20 clusters assume to cover all data variation.

K-mean statistical technique used to seed input data in to given clusters by assume initial guess mean value for each cluster for each input loge data and then try to minimize sum of squares deference within cluster between data points and cluster mean value.

The 20 cluster consolidated by hierarchal technique which based on compute distance between clusters and merger two closest clusters in distance then return compute the distance between new clusters and re-merge the two new closest clusters .the processes done until all clusters merged in one cluster.

Consolidating of the clusters into a known number of rock types is easily indicated by Cluster Randomness Plot done by plot random thickness index vs. number of clusters.

The randomness is performed on original logs data by calculating the average number of depth levels per cluster which represent the average cluster thickness layer.

Then the theoretical average random thickness is determined by assuming the clusters to be assigned randomly at each depth level.

The randomness index represents the ratio of average cluster thickness to average random cluster thickness [3].

Av. Thickness = Number of depth levels / Number of cluster layers (2)

Random Thickness $= \Sigma\, pi / (1 - pi)$ (3)

Where, pi is the proportion of depth levels assigned to the i-th cluster.

Randomness index = Av. Thickness / Random Thickness (4)

Randomness plot for tertiary reservoir shows four groups can be depend as rocks types by collecting the number heights peaks as shown in the Fig. 1.

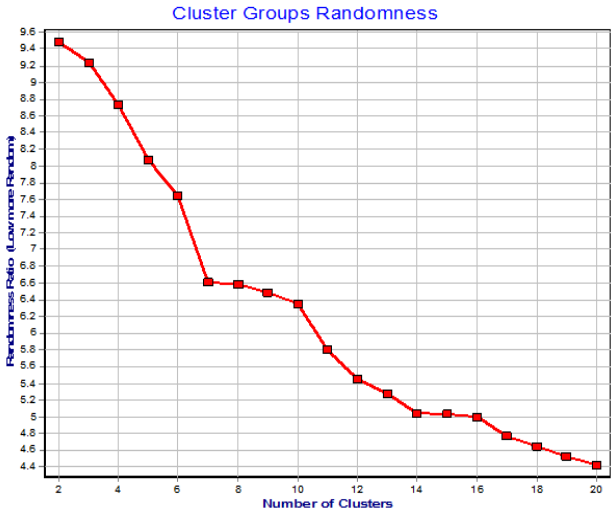

Fig. 1. Cluster group's randomness for tertiary reservoir in Khabaz field

The hierarchal technique shows merging process of rock type in groups distinguished by different colors explained in tree- diagram as shown in Fig. 2.

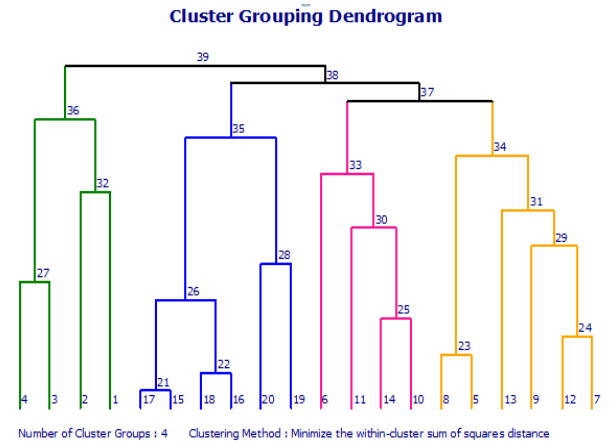

Fig. 2. Cluster grouping tree diagram for Tertiary Reservoir in Khabaz Field

Table 1. Cluster analysis results for each Rock type

K-Mean Clusters Results												
CLUSTERS			PHIE		SW		DT		K		RHOBC	
cluster	Groups	Points	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.
1	1	343	0.24	0.03	0.35	0.21	74.30	5.17	296.64	61.22	2.29	0.08
2	1	421	0.22	0.02	0.16	0.09	77.19	4.11	182.19	34.16	2.31	0.04
3	1	640	0.20	0.03	0.36	0.16	69.13	2.88	147.90	31.49	2.40	0.04
4	1	677	0.18	0.02	0.20	0.10	72.66	3.62	85.00	23.52	2.39	0.05
5	2	696	0.15	0.03	0.22	0.10	68.25	2.86	13.98	11.98	2.45	0.03
6	3	194	0.19	0.04	0.86	0.14	74.13	4.43	45.79	41.95	2.44	0.06
7	2	586	0.08	0.02	0.40	0.14	65.55	2.80	2.28	4.01	2.52	0.04
8	2	678	0.17	0.04	0.51	0.10	66.05	2.59	22.18	20.60	2.49	0.04
9	2	437	0.14	0.04	0.22	0.11	58.88	3.46	23.20	20.54	2.46	0.06
10	3	585	0.16	0.03	0.88	0.11	67.15	2.86	9.44	9.61	2.45	0.04
11	3	517	0.07	0.03	0.95	0.09	68.69	3.14	0.49	1.09	2.55	0.05
12	2	705	0.12	0.02	0.50	0.14	60.38	2.16	7.82	9.43	2.56	0.03
13	2	692	0.06	0.02	0.42	0.15	55.64	2.74	0.80	3.07	2.60	0.05
14	3	940	0.12	0.02	0.95	0.08	63.97	2.28	4.21	5.22	2.53	0.03
15	4	1134	0.08	0.02	0.98	0.06	61.45	1.61	0.38	1.20	2.60	0.03
16	4	615	0.02	0.02	0.99	0.06	62.04	2.43	0.01	0.01	2.63	0.05
17	4	810	0.08	0.02	0.95	0.09	56.82	1.92	0.48	2.19	2.58	0.04
18	4	1478	0.05	0.02	0.99	0.05	57.92	1.58	0.03	0.07	2.65	0.03
19	4	816	0.02	0.02	0.98	0.07	53.06	1.97	0.02	0.07	2.68	0.04
20	4	207	0.00	0.02	1.00	0.00	54.65	3.28	0.01	0.01	2.83	0.05

The quality of four rocks types identified from k-mean values of petrophysical properties which are used as input parameter for cluster analysis that tabulated in the Table 1.

According to k-mean values for each cluster within rock type groups each group given grad as:-

- Best quality rock type
- Good quality rock type
- Moderate quality rock type
- Bad quality rock type

Final graphical of cluster analysis for selected wells in this paper explained in the Fig. 3

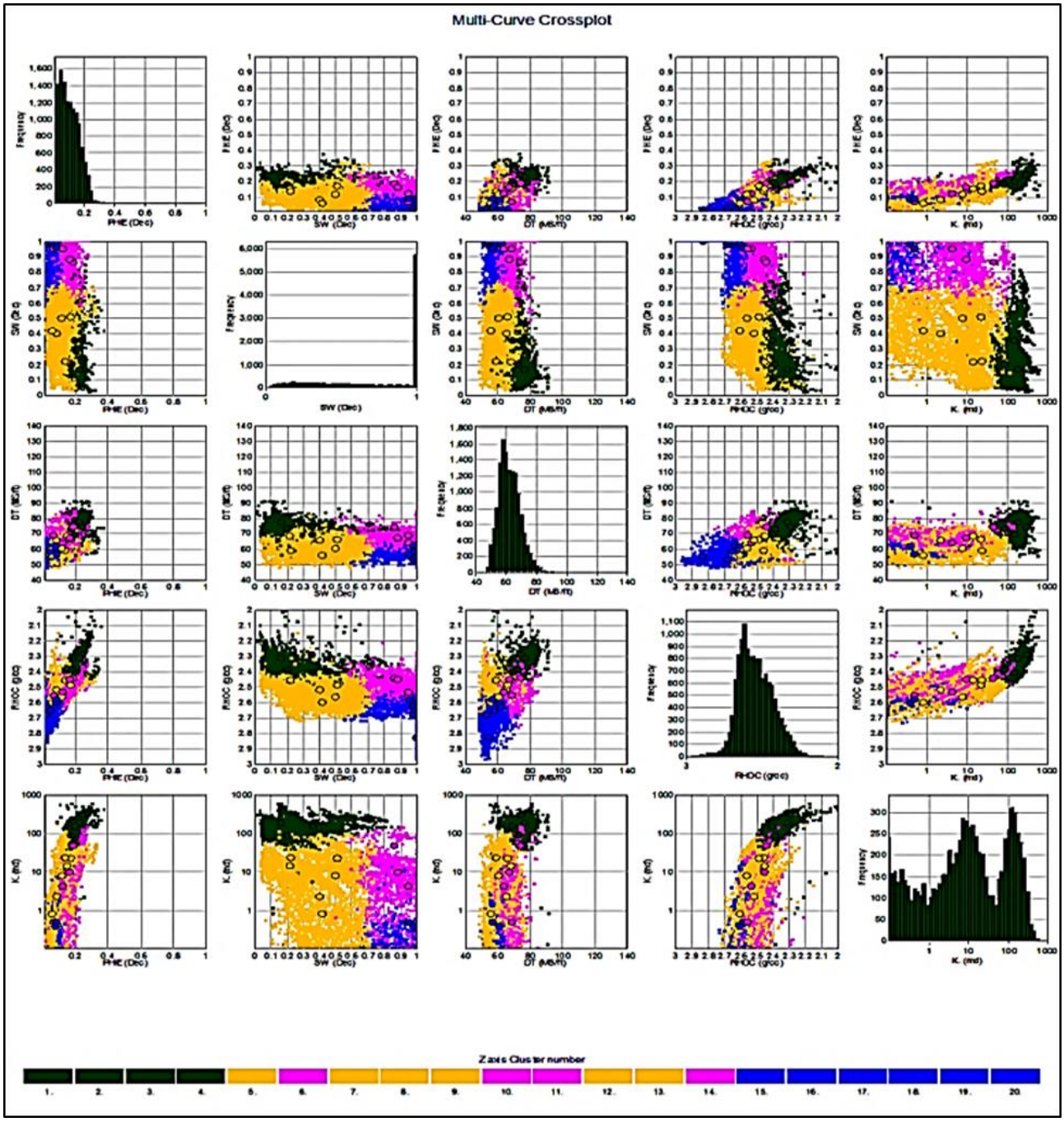

Fig. 3. The final graphical result of clustering analysis

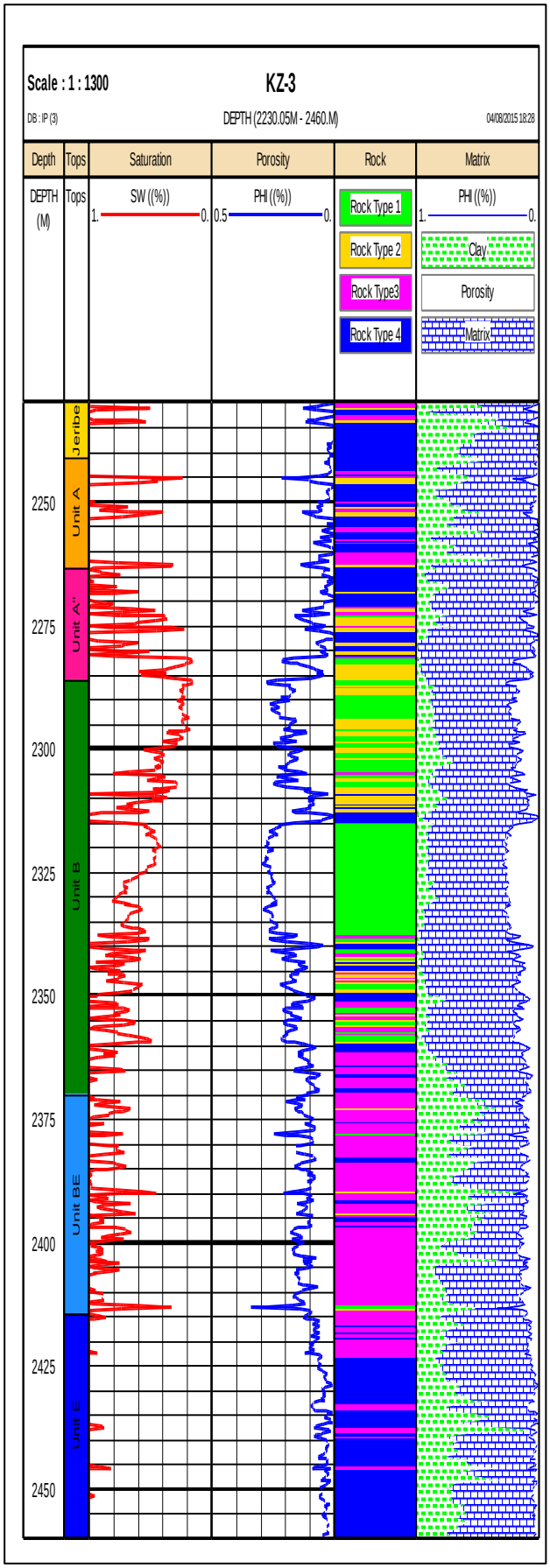

Fig. 4. Rock type for Kz-2 by cluster analysis method

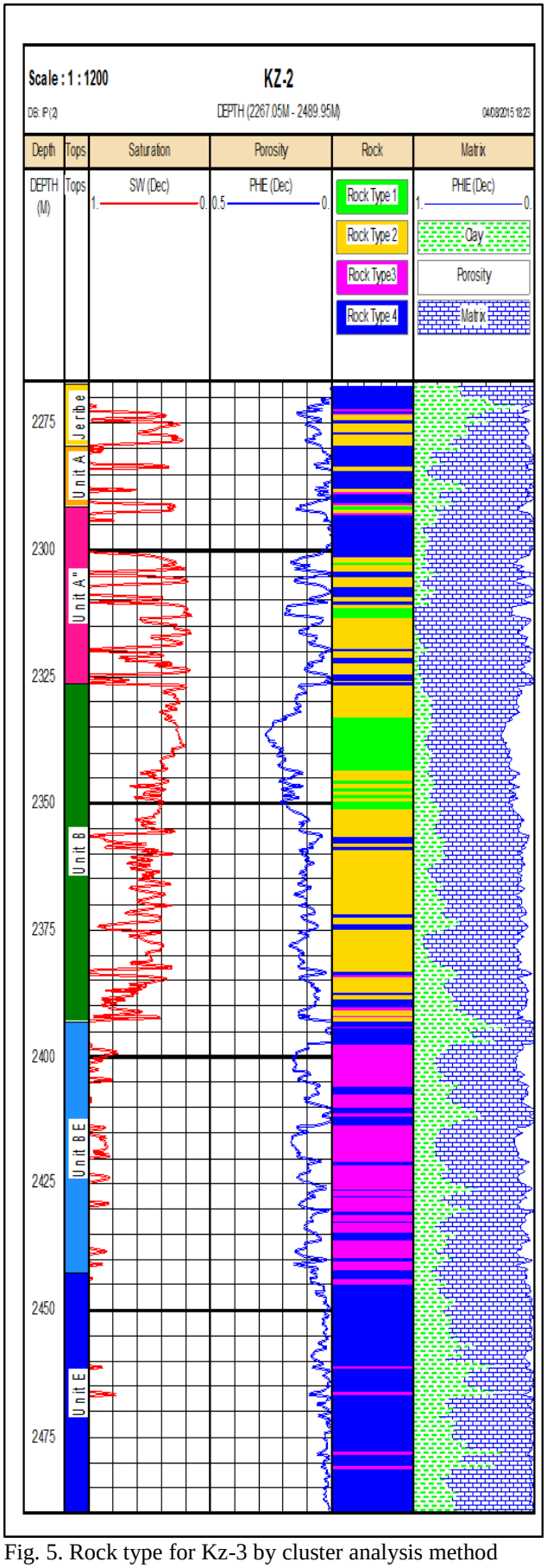

Fig. 5. Rock type for Kz-3 by cluster analysis method

3- Conclusion

Cluster analysis is a simple method can be used to identify rock type fore reservoir depending on log data.

1- Cluster analysis of log data for wells that penetrated tertiary reservoir shows that the tertiary reservoir can be divided in four groups as shown in roundness plot.
2- Plotting rock type in continuous form in selected wells shows that the unit B is the most interested zone in tertiary reservoir for Khabaz oil field.

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