

Dynamis and static electrofacies analysis versus HFU in Ilam Reservoir; a carbonate oil field of Iran

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Introduction

In this study, new static and dynamic aspects of electrofacies analysis have been performed in order to check relationship between static and dynamic electrofacies with HFU and petrophysical parameters with different electrofacies in Ilam reservoir in one Iranian oil field. This formation is carbonate reservoir and composed of four reservoir zones according to integrated sequence stratigraphic, geological and petrophysical studies.

In this study, after trying different approaches, Multi regression graph-based clustering (MRGC), Self-organizing map (SOM) and Ascendant hierarchical clustering (AHC) have been used for special electrofacies analysis. Electrofacies as introduced by Serra and Abbot is defined as the result of a set of well log responses, which characterizes a bed that can be distinguished from the adjacent ones [1]. Since permeability is a key log to convert electrofacies from static state to dynamic, then it has been used as input data for dynamic electrofacies analysis. After considering the statistical distribution range of porosity, lithology and other petrophysical parameters; finally, 6 electrofacies have been selected as a base clustering number for all cases in order to be compared. MRGC is a multi-dimensional dot-pattern recognition method based on non-parametric K-nearest-neighbor and graph data representation [2]. It gives clusters on the ground of distribution of natural points (local Density) at different scales [3] [4]. The SOM, which known as Kohonen network, is a computational method for the visualization and analysis of high-dimensional data, especially experimentally acquired information [5]. AHC is a statistical method for finding relatively homogeneous clusters of cases based on measured characteristics [6]. It starts with each case in a separate cluster and then combines the clusters sequentially, reducing the number of clusters at each step until only one cluster is left.

Methods

In this study, SOM, MRGC and AHC algorithms have been used for electrofacies analysis. In addition, FZI concept has been used for HFU determination and in turn for permeability prediction. Some petrophysical logs such as porosity, predicted permeability, mineral volumes, CGR, DT, NPHI and RHOB have been used as input data for electrofacies analysis.

Geological setting

Type section of Ilam Formation was studied in northwest of Kabirkoh by James & Wynd [7]. The Ilam formation is composed of limestone with some intercalated shaly layers and forms the main reservoir in the studied field. The thickness of the Ilam formation in this field is about 120m. This formation overlays the Surgah/Laffan formation. Its upper contact with the Gurpi formation is conformable. The age of the Ilam formation is Santonian to Campanian [8].

Discussion

Hydraulic flow unit (HFU) determination and Permeability prediction:

The hydraulic flow unit is the representative elementary volume of the total reservoir rock within the geological and petrophysical properties of the rock volume [9]. More researches about application of HFU in reservoir characterization have been published [10, 11, 12]. Kozeny suggested the first

empirical equation relating measurable rock properties with permeability by using bundle of straight capillary tubes model with constant and uniform surface area [13]. Amaefule et al. introduced a new practical and theoretically based technique which has been developed to identify and characterize units with similar pore throat geometrical attributes (hydraulic units) [14]. According to HFU analysis two rock type have been determined. After that, HFU results have been used for permeability prediction according to following equations derived for each rock type:

$$\text{Rock type-1: LOG (perm)} = 11.439 (\text{phie}) - 2.6453 \quad [1]$$

$$\text{Rock type-2: LOG (perm)} = 10.138 (\text{phie}) - 1.89 \quad [2]$$

Electrofacies analysis

Since according to Hear et al. flow unit is defined as a reservoir zone that is laterally and vertically has similar permeability, porosity, and bedding characteristic [15], therefore, we tried to find this clusters via electrofacies analysis in two following methods.

Case 1- Static electrofacies analysis (Unsupervised algorithm)

Some petrophysical logs such as porosity, predicted permeability, mineral volumes, CGR, DT, NPHI and RHOB have been used to define electrofacies according to relationship results between imported logs obtained from checking relative cross plot. Unsupervised algorithm has been applied after training and normalizing the input data.

After preparing the normalized input data, MRGC, AHC and SOM algorithms have been used among other different approaches for electrofacies analysis of first reservoir. All applied methods allow the user to obtain clusters and ideal electrofacies numbers for defining lithological electrofacies from conventional logs, geological microfacies, image logs and so on. After considering the statistical distribution range for porosity, lithology and other petrophysical parameters, 6 electrofacies for all 3 algorithms have been selected as base clustering cases.

Case2 Dynamic electrofacies analysis (supervised algorithm)

In this case the same logs as selected in static case have been applied for electrofacies analysis along with using permeability as an input data. Unsupervised algorithm has been applied after training and normalizing the input data. After preparing the normalized input data, MRGC, AHC and SOM algorithms have been used for electrofacies analysis. Finally, 6 electrofacies for 3 methods have been selected as base clustering cases (Figure-1).

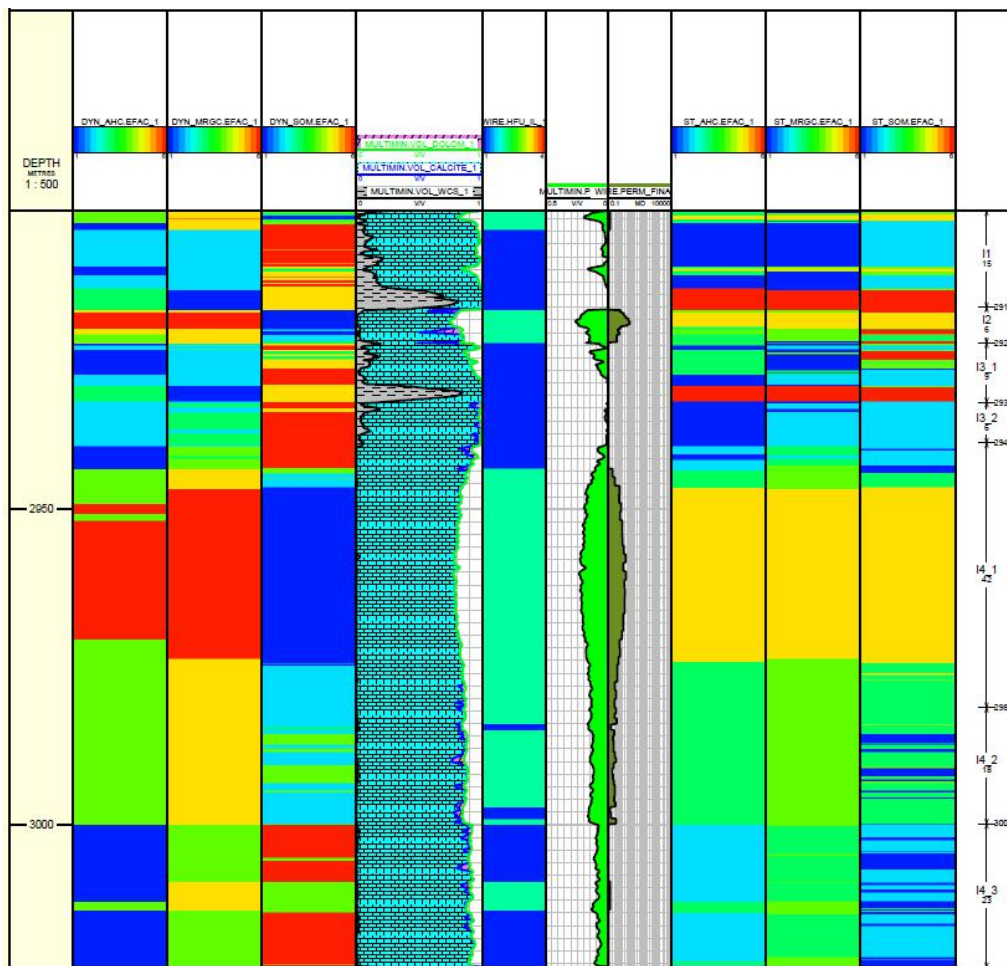


Figure 2 Six suggested electrofacies models (MRGC, AHC and SOM for static and dynamic cases) versus, porosity, permeability, lithology and HFU

Conclusions

In this study, 6 static and dynamic electrofacies models have been generated using MRGC, SOM and AHC methods in order to check relationship between static and dynamic electrofacies with HFU in studied field. Some petrophysical logs such as porosity, predicted permeability, mineral volumes, CGR, DT, NPHI and RHOB have been used as input data for electrofacies analysis. Based on this study, both static and dynamic electrofacies (without and with applying permeability log as an input data) can detect pay zones from, others considering the HFU. However, electrofacies can identify shaly zones (poor reservoir or seal) from other payzones.

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