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EA The Study of the Oligocene Electrofacies in the Paratethys Region*

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Abstract

The identification of lithofacies relies on core data analysis which can be expensive and time consuming as against the electrofacies which are straight forward and inexpensive. To date, challenges of interpreting as well as correlating well log data has been on the increase especially when it involves numerous wellbores that manual analysis is almost impossible. An accurate and proper understanding of the hydrocarbon reservoir requires a comprehensive study of the sedimentary and diagenetic characteristics of reservoir rocks. Integration of different geological and petrophysical studies has an important role in identification of production zones and main factors controlling the reservoir quality. Well logs have the advantage, over cores, of providing a continuous record over the entire well and can be obtained in conditions where coring is impossible. Therefore, well logs data can give a good lithologic description of formations. This paper investigates the possibilities for an automatic stratigraphic interpretation of a Kliwa Sandstone reservoir in the Paratethys region in Romania through statistical pattern recognition and rule-based method. The idea involves seeking high density clusters in the multivariate space log data, to define classes of similar log responses. A hierarchical clustering algorithm was implemented in each of the wellbores and these clusters classify the wells into four classes that represent the lithologic information of the wells. These classes known as electrofacies are calibrated using a developed decision rules which identify four lithologies, Sandstone, Argillaceous Sandstone, Sandy Shale and Shale in the well logs data. These can form the basis of correlation to generate a subsurface model. Thus, separation of reservoir facies based on available logs known as log facies or electrofacies, can be used as a useful, practical and economical procedure in this regard. In addition, study of the recognized electrofacies from petrophysical point of view and in relation to hydraulic flow units, provides a suitable understanding of the reservoir properties and production zones. Pattern recognition methods are used to identify the patterns of the wireline log reading from wellbore. This paper explores the opportunity of automating the interpretation and analysis of well log data of gamma ray, neutron and density logs using a statistical pattern recognition approach. The objective of this paper was to use the computer software algorithm which similarly stores log curve shape information for various lithologies and interprets new data by comparing the known shapes to unknown data. The interpretation algorithms were tested on logs from 3 wells drilled in the Runcu-Bustenari region of the Moesian Platform. The classifier produced the best results for this homogeneous clastic lithology. In conclusion, advances in computer hardware technology now make it possible for many of these interpretation techniques to

be performed on an inexpensive, desktop computer. The results showed that cluster analysis is a precise, rapid, and cost-effective method for zoning reservoirs and determining electrofacies in hydrocarbon reservoirs.

Introduction

An accurate and proper understanding of the hydrocarbon reservoir requires a comprehensive study of the sedimentary and diagenetic characteristics of reservoir rocks. Integration of different geological and petrophysical studies has an important role in identification of production zones and main factors controlling the reservoir quality.

Subsurface lithology is traditionally determined from cores. Cores are not continuous and do not provide complete descriptions of formations crossed by a well. Well logs have the advantage of providing a continuous record over the entire well and can be obtained in conditions where coring is impossible. Therefore, well logs data can give a good lithologic description of formations. Thus, separation of reservoir facies based on available logs known as log facies or electrofacies, can be used as a useful, practical and economical procedure in this regard. In addition, study of the recognized electrofacies from a petrophysical point of view and in relation to hydraulic flow units, provides a suitable understanding of the reservoir properties and production zones.

Pattern recognition methods are used to identify the patterns of the wireline log reading from wellbore. This paper explores the opportunity of automating the interpretation and analysis of well log data of gamma ray, neutron and density logs using a statistical pattern recognition approach. The techniques for building a computer-aided interpretation system can be found in the rapidly developing fields of pattern recognition and applied artificial intelligence. Pattern recognition techniques include feature extraction, clustering and classification of groups within a set of data. Feature extraction refers to the calculation of parameters which are representative of a large set of data.

The objective of this paper was to use the computer software algorithm which similarly stores log curve shape information for various lithologies and interprets new data by comparing the known shapes to unknown data. The algorithm which was developed processes the data in three stages: first by zoning the log into subintervals, then by characterizing the interval with various shape parameters, and finally by performing statistical pattern recognition to classify the interval.

Geological Uses of Well Logs

The geologic information in a suite of well logs must be extracted from the log measurements, which indirectly measure the physical properties of the rock. The indirect representation of the lithology within the log trace has prompted the use of the term “electrofacies” to describe geologic units determined from logs. Well logs have become more accurate as technology developed and presently allow initial analysis of many aquifers and oil fields to be done based only on the log interpretation. To fill the lack of rock samples and to avoid harming the assessment on the interval of interest, combined log analysis is a common practice. It allows estimate, for instance, the kind of rock, to recognize permeable layers, to identify intervals bearing hydrocarbons and to determine the percentage of rock porosity.

Example - Gamma-Ray Log

This measures the natural gamma-ray emission of the various layers penetrated in the well, a property related to their content of radiogenic isotopes of potassium, uranium and thorium. These elements (particularly potassium) are common in clay minerals and some evaporites. In terrigenous clastic successions, the log reflects the "cleanness" (lack of clays) or “shaliness”, high radioactivity on the API scale, of the rock (Figure 1).

There are three main interpretation problems with the gamma-ray log:

1) the log response may be affected by diagenetic, radioactive clays in pores
2) shales rich in illite (high K) are more radioactive than those rich in montmorillonite or chlorite
3) arkosic sandstone (rich in feldspar) are more radioactive than those lacking feldspar

Calibration of the log against cores or cuttings may be necessary to distinguish lithologies in some cases.

Facies Analysis

The electrofacies analysis in this paper was done in the inferior Kliwa formation (Kliwa II) from Oligocene-Solz II. The reservoir is very well developed and was divided into four thick (50-150 m) sandy-sandstone complexes named from top to bottom Kliwa II C I, C II, C III and C IV. The main productive areas being C III and C IV. To determine and differentiate different types of electrofacies in the reservoir, well log data from Oligocene Formation from three wells of the Runcu field are used. Well log data used are gamma ray (GR), density (RHOB) and neutron (NPHI) logs. Core porosity and permeability data are not available for all wells.

The Oligocene reservoir from Runcu, Solz II, was selected for the application of this method. Three wells were selected in the Kliwa II reservoir. The productive strata is sandstone and the formation is relatively homogenous (Figure 2).

The stages of electrofacies analysis can be summarized in the following way:

1. Reading of the raw values and controlling the recordings, considering several factors and parameters;
2. Choice of the data of interpretation, considering several factors and parameters;
3. Facies analysis study;
4. Study by analysis of the depositional environments and the sedimentary systems.

In this paper the cluster analysis technique based on cluster tree is used for grouping data and identifying reservoir electrofacies.

Cluster Analysis, also called data segmentation, relates to grouping or segmenting a collection of objects (observations, individuals, cases, or data rows) into subsets or "clusters", such that those within each cluster are more closely related to one another than objects assigned to different clusters.

The purpose of cluster analysis is to look for similarities/dissimilarities between data points in order to group them into classes. In multi-dimensional space logs, the distance between data points is a measure of their dissimilarities. Samples with similar log responses will tend to form clusters, separated by areas with a lower density of points. The points are close due to the similarity of log their response. The idea is to ascribe to each level of the well the group or cluster to which it belongs. Statistical theory provides two types of approach (Gnanadesikan, 1977).

The second approach which was used here is to determine the clusters or groups from the data in each well. This “clustering” has a merit of letting the data “speak for themselves” and reveals their subtle differences. However, geologic interpretation of the cluster must be repeated each time.

Conclusions

The method described in this thesis resides in the automatic classification of stratigraphic column via statistical pattern recognition of the well log data. A hierarchical clustering algorithm was implemented in each of the wellbores and these clusters and classifies the wells in four classes that represent the lithological information of the wells. These classes known as electrofacies identify the lithology of the three wells.

The method also resides in the use of generated electrofacies as an exploration tool for identifying sand bodies which serve as the oil reservoir rocks. As no core was available, the samples were calibrated based on the qualitative interpretation of well logs over a set of cuttings descriptions. It also saves valuable time in manual analysis. The detailed knowledge of the geological settings of the study area helps to understand the general stratigraphic sequence and constitute a strong base for any automatic lithological classification. The whole process is automated based on a set of decision rules and the results forms the basis of correlation between wells in the study area.

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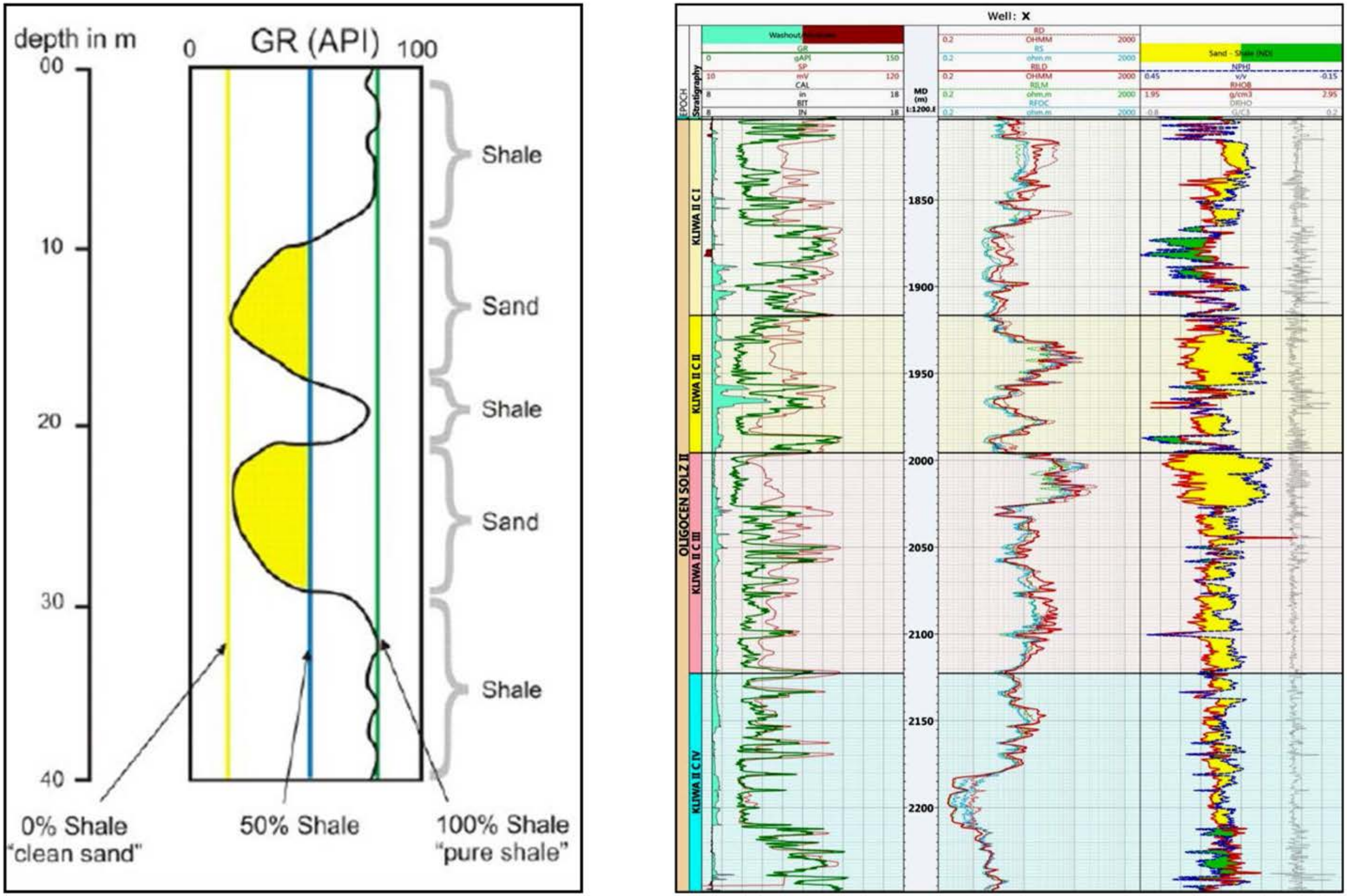

Figure 1. Classic interpretation of a Gamma-Ray log; example of the interpretation in the first stage.

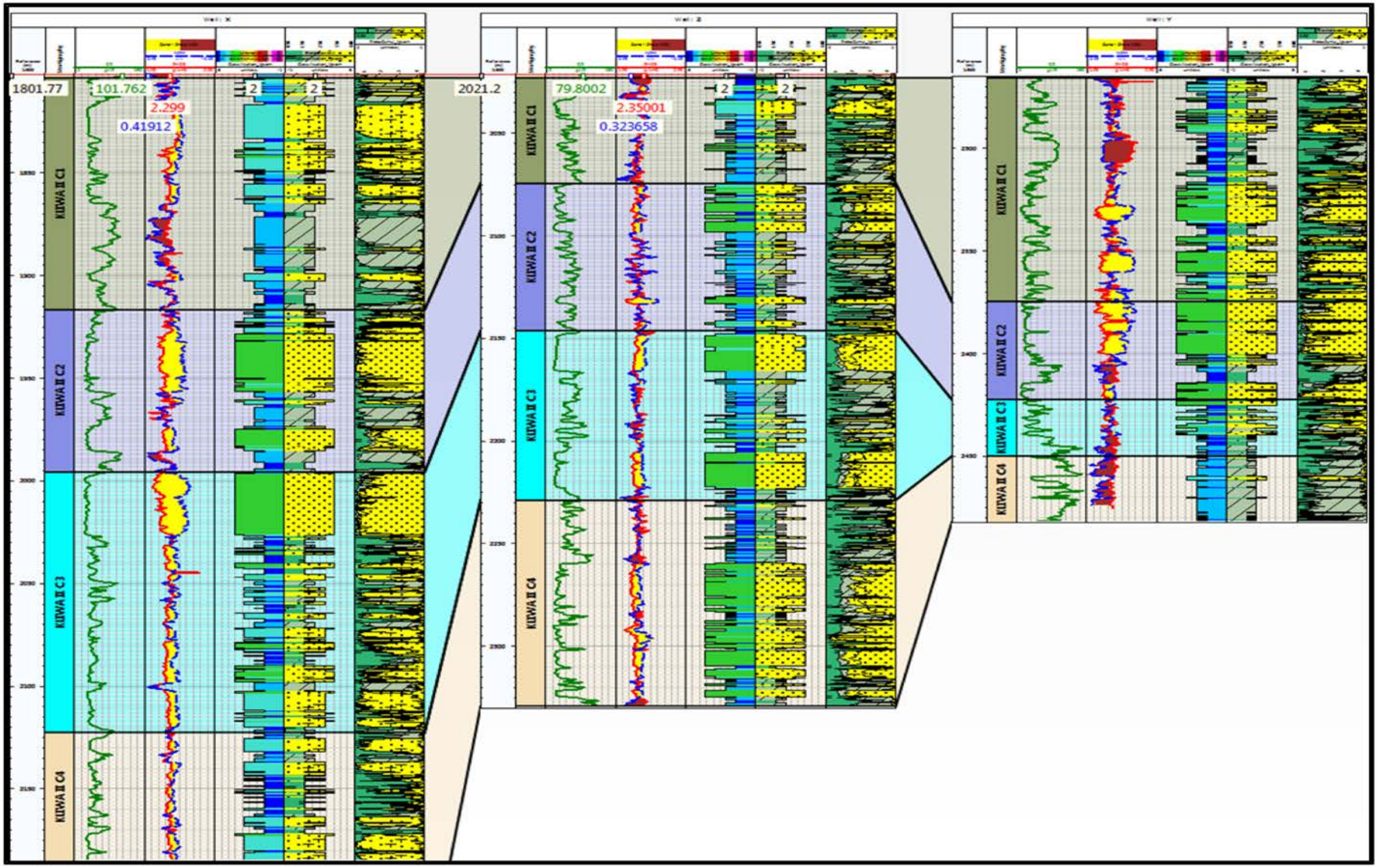

Figure 2. The electrofacies obtained in the three wells.