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Modeling Permeability in Tight Gas Sands Using Intelligent and Innovative Data Mining Techniques

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Abstract

Evaluation of gas potential in low permeability reservoirs (< 0.1 md) generally referred to as Tight Gas reservoirs is not very straight forward as in conventional reservoirs. This study is focused on modeling permeability in the Travis Peak Formation where there are many challenges. One may encounter low resistivity pay due to clay coated grains and alternating thin laminae of finer and coarser sandstones with distinctly different pore geometries, natural fractures, bituminous zones and multilateral fluvial channel sandstones in broad lenses. Core data is sparsely available. Most importantly, there are no structural features that may construe trapping mechanisms. In view of these challenges, a permeability model was developed primarily for the Travis Peak Formation of Robertson and Leon counties where it has produced 96 BCF of gas and 0.54 MMbbl of oil.

A permeability model was developed by integrating core and log data using the Adaptive Neuro Fuzzy Logic Inference System (ANFIS) that combines the functionality of neural network and fuzzy logic techniques. A combination of conventional logs such as lithology (GR, SP), porosity (RHOB, NPHI), deep and shallow resistivity logs were integrated with core data (porosity, permeability).

The results showed excellent agreement with measured core permeability values. The results of the conventional porosity-permeability transform are also presented for comparison purposes. Since the data has been used from the Travis Peak Formation of East Texas Basin comprising several counties, it is expected that the permeability model should be applicable anywhere in the basin.

Introduction

Permeability is the most important and difficult reservoir property to determine and predict. A great deal of effort has been demonstrated in the literature to come up with an applicable, workable permeability model based on conventional logs. This is because the logs are the least expensive method of obtaining information about the subsurface formations compared to coring. Cores are usually obtained from less than one percent of the wells in a given field. In addition, not all possible logs are run because of the economic considerations.

The logs provide valuable information about the subsurface strata. Gamma ray (GR) and Spontaneous Potential (SP) logs provide information concerning the lithology of the formation. Resistivity logs provide information regarding the presence of hydrocarbons and the relative mobility of the fluid in the formation. Porosity logs (Neutron, density and sonic) provide information concerning porosity of the formation, help differentiate between hydrocarbons and, in some cases, provide valuable information regarding natural fractures in the formation.

The quest for determining permeability from well logs has been there for decades. A review of permeability prediction methods using well logs has appeared recently.¹ Researchers have adopted statistical and geostatistical approaches to determine or predict permeability from well logs.²⁻⁵ These approaches are not discussed here. However, use of novel intelligent techniques that have become available in recent years is discussed. These techniques are Artificial Neural Network (ANN), Genetic Algorithm (GA) and Fuzzy Logic. The trend is to use them in combination with each other as well as with statistical techniques in hybrid fashion. Several studies have appeared in the literature that model permeability using well logs.