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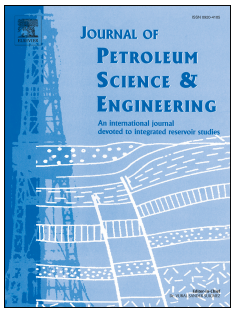

Estimation of permeability and effective porosity logs using deep autoencoders in borehole image logs from the brazilian pre-salt carbonate

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Estimation of permeability and effective porosity logs using deep autoencoders in borehole image logs from the brazilian pre-salt carbonate

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ABSTRACT

Rock permeability and porosity are some of the most important features to be determined during the exploitation of a certain hydrocarbon reservoir, as these physical properties help petrophysicists understand the most likely distribution and/or presence of oil/gas reservoirs, as well as decide whether that certain field might be exploitable or not. Despite their importance, in order to obtain permeability and porosity values it is usually required to run tests on borehole core samples that are either destructives or that need to be done under very controlled conditions, which makes them very expensive and time consuming. In the last decades, some authors have been able to estimate both these properties measurements from well-logging reservoir curves –such as Gamma-Ray response (GR), Bulk Density (RHOB) or Neutron Porosity (NPHI)–. In this study, we present a novel method that can be used to estimate formation permeability and porosity from borehole image logs –instead of simple logs– using deep autoencoders. The data used in this work belongs was extracted from a Brazilian pre-salt carbonate well. First, we use a 3–level stacked autoencoder to extract internal features from both ultrasonic and microresistivity images, thus characterizing the features contained inside these images. Afterwards, we use a support vector machine regressor (SVM) to link the encoded features extracted from the autoencoders for each type of data (ultrasonic and microresistivity borehole images) to the petrophysical measurements logs. Using this method we were able to achieve a correlation coefficient between original and estimated validation samples of $R^2 = 96.30\%$ for effective porosity logs and $R^2 = 96.06\%$ for permeability logs, and a normalized squared mean error of $NMRSE = 7.30\%$ and $NMRSE = 5.51\%$, respectively, all results in the blind test sample.

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1. Introduction

One of the most important tasks required before any reservoir production begins is field characterization. Obtaining measurements about the petrophysical properties of the reservoir is important not only for the geological modeling of a given hydrocarbon accumulation but also to support fluid flow scenarios in an occasional production routine (Crafton et al., 1997).

In particular, effective porosity and permeability measurements are very important in field characterization and reservoir production viability analysis, although obtaining these measurements is often difficult and very expensive.

Estimating petrophysical properties from well-logs is considered a valid solution which can provide results with a reasonable level of accuracy (Mohaghegh et al., 1995; Perez et al., 2005; Hamada and Elshafei, 2010; Abdideh, 2012; Rafik and Kamel, 2016; Elkatatny et al., 2017; Menezes et al., 2016). On the other side, Deep networks (LeCun et al., 2015; Schmidhuber, 2015) have revolutioned the methodologies applied in artificial intelligence, as it allows us –among other things– to

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