Case Study: Seismic Porosity Estimation in an Offshore Atlantic Canada Carbonate Field

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Introduction

The deep Panuke field is located 250 kilometers southeast of Halifax, Nova Scotia. This natural gas field is located within the margin of the carbonate platform (Abenaki Formation) that was formed along the East Coast of North America during the opening of the Atlantic Ocean in the Middle to Late Jurassic. The reservoir is at a depth of about 3500 m and is made up of porous limestone and dolomite. Since 1999, PanCanadian has drilled four wells in the field, that have tested reservoir at variable quality at rates in excess of 50 million cubic feet of gas per day. This discovery is the most significant in Atlantic Canada in more than a decade.

One critical issue for reserve calculation and production planing is the estimation of the distribution of porosity. This paper is a technical discussion of two different strategies to employ neural networks for optimal porosity estimation from surface 3D seismic data.

Methodology

The first part of this study is a sensitivity analysis of seismic attributes to predict porosity.

In this sensitivity analysis “seismic” log data were correlated to log porosity data to determine the most suitable attributes for porosity prediction. The investigated seismic log data include amplitudes from synthetic seismograms computed from P-velocity and density, P- and S- impedance, and LMR™ data. The P- and S-impedances proved to be the most important attributes, the amplitude data was less sensitive and the LMR data did not yield additional information than that already in the impedance data and therefore was redundant for a neural network based prediction.

P- and S-impedance were used simultaneously as inputs to train neural networks for porosity prediction. Several architectures of neural networks were tested from which one was selected to estimate a 3D-porosity cube from respective seismic attributes, which were extracted from the 3D seismic cube. Two strategies of neural network training will be described in this paper:

1) Training neural networks on real log data, verifying the net on real log data, which were not included in the training, and employing the trained neural network on 3D seismic data.
2) Training neural networks on simulated well logs, verifying the nets on real well logs, and applying the neural network on the 3D seismic.

Results

Qualitatively a good prediction of the porosity distribution was achieved. An exact quantitative prediction was challenged by the problem of an accurate scaling, which would allow a neural network trained on log data to be applied on real data. The neural network predicted porosity was underestimated due to these scaling problems. However, a final scaling of the output satisfactorily minimized this problem. A comparison of the results of the two discussed strategies demonstrated the first method to be superior for this particular application.