Quantitative Reservoir Characterization

Introduction

Various kinds of geophysical data are available. They are usually separated into Seismic and Multi-Physics data, which used to be called Non-Seismic data. Seismic is, without any doubt, the main method used in the oil and gas industry. But Multi-Physics data (gravity, magnetics, electrical, electromagnetics, spectral, etc.) is the main source of information in shallow subsurface applications (engineering, mapping pollution, archaeology, etc.) and at the early basin reconnaissance stage. However, seismic has its limitations and therefore also multi-physics methods are used successfully as complementary tools in subsurface evaluation. In combination with seismic data, they can significantly reduce the uncertainty of subsurface models as they measure different physical properties of the subsurface. In this course we will only use seismic. In another " Multi-physics" course all data will be considered.

Seismic data and Processing

From seismic we not only need to obtain the structure that could contain hydrocarbons, but also the rock properties so we can decide on whether we are dealing with reservoir rocks (sandstone, carbonates, even shales), sealing rocks (shales, salt) or source rocks (shales, coals). To know what type of rock is present is important, but also what its porosity is and whether it is fractured, as that is important for permeability (How easy do the hydrocarbons flow through the rocks). To obtain accurate information on the rock properties we need, in principle, to consider two-way elastic wave propagation. Considering elastic propagation, which includes mode conversion, is necessary when we analyze the (pre-stack) amplitude variation with offset (AVO) or more accurately defined as amplitude variation with angle of incidence (AVA).

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From quantitative analysis of pre-stack migrated seismic data, elastic properties of the reservoir can be derived. But these need to be translated into rock properties relevant for exploitation, that is porosity and fluid saturations. That means that a rock-physics model need to be chosen. For clastic reservoirs that is relatively easy, for carbonate reservoirs it is much more non-unique. Therefore, in the course extensive use is made of Differential Effective Medium (DEM) methodology to build realistic rock models. For AVA analysis the overburden shale is taken to be Tranverse Isotropic (TVI), due intrinsic anisotropy of the shale platelets and for the reservoir Backus averaging of sandstone-shale layers is applied to calculate an effective homogeneous TVI medium or when vertical fractures are added to result in an Orthorhombic anisotropy medium. Also inversion of AVA attributes, derived from Intercept, Gradient, Curvature and Azimuthal attributes are applied in exercises. Extensive use is made of Google Colab or the laptop GPU, if available.

The Course

The above items will be dealt with in the course; by presentations and discussions, watching videos and by doing many practical exercises using either Excel or open-source software. Also, each day contains a multiple-choice quiz which is meant to reinforce the learning. In addition, we will investigate in an exercise how best can we make use of a large language model (ChatGPT).