Seismic Analysis of Well Data—Minimizing Uncertainties from Seismic Interpretation to Reservoir Characterization

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Summary

One of the leading challenges in hydrocarbon recovery is predicting lithology and fluid distribution away from wells. Well data contains critical information regarding subsurface and reservoir properties, but it is sparse. Seismic analysis of well data can reveal the potential to discriminate between the target reservoir and the background geology using elastic properties. Testing frequency content, noise and multiple contamination, and the resulting AVO response during seismic analysis data, all inform the interpreter of the feasibility of imaging the petroleum bearing zone in different seismic quality scenarios. This awareness will guide interpreters in seismic acquisition requirements and essential processing methods to mitigate insufficient results.

Introduction

Well data contain valuable and detailed information about the subsurface geology along the wellbore, but wells sparsely sample geology spatially (White, 2003). Seismic data on the other hand, has dense spatial sampling but lacks vertical resolution. Synthetic seismograms allow geoscientists to blend the best of both datasets relating geology to elastic properties—which are meaningfully related to seismic data. The seismic analysis of well data begins cannot be done without synthetic seismograms. Seismograms are primarily used qualitatively, correlating well logs to seismic data in the time domain, but they also crucial in modeling the elastic properties for quantitative seismic assessments. Leveraging dipole sonic logs, geoscientists can reasonably assess the efficacy of resolving key elements of the reservoir to discriminate the lithology and fluid distribution within (Batzle, 1992 and Avseth, 2005). The seismic analysis of well data can help geoscientists assess the reliability of using seismic to reveal rock property distribution. It can also help to inform discussions with acquisition and processing companies concerning future projects and data quality requirements for accurately delineating reservoir properties

Theory

Synthetic seismograms use rock properties measurements contained in log data to relate the physical changes in the geology to a modelled seismic response. This begins with creating an impedance curve (velocity • density) to determine a reflectivity log (the relative changes in impedance). The reflectivity log is then convolved with a wavelet to create a representative, zero-offset (acoustic) seismic trace (Figure 1). This process can also be applied to non-zero offset (elastic) modeling to estimate AVO and AVA behavior.

There are several assumptions inherent with synthetic seismograms about the seismic data, well data, and the seismogram itself. Fundamentally they come down to these two:

1. Seismic is prescriptive of the geology. If the seismic data in the region around the well is noisy, this will impact the synthetic model. Any problems with the log data or the well location relative to the seismic will also impact the result.

2. The log data accurately characterizes the geology. Correcting for environmental factors such as mud invasion and washout zones will increase the reliability of the seismogram. The same can be said for removing elements such as cycle skipping or other artefacts (Figure 2, Walls, 2004).

Other impacts of assumptions and workflows for building seismograms are detailed in Anderson and Newrick, 2008.

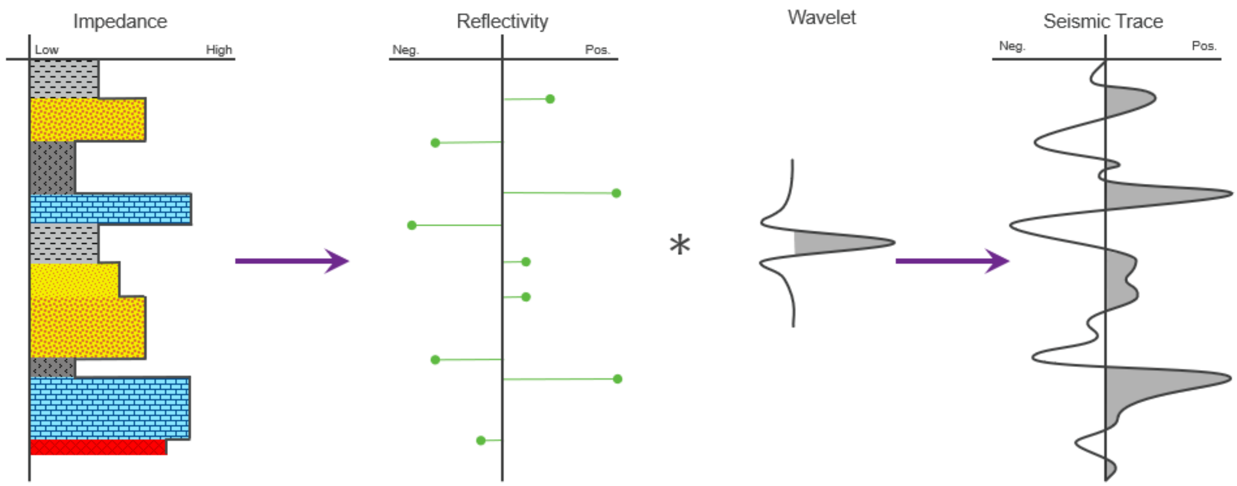

Figure 1. *Schematic process for creating a synthetic seismogram.*

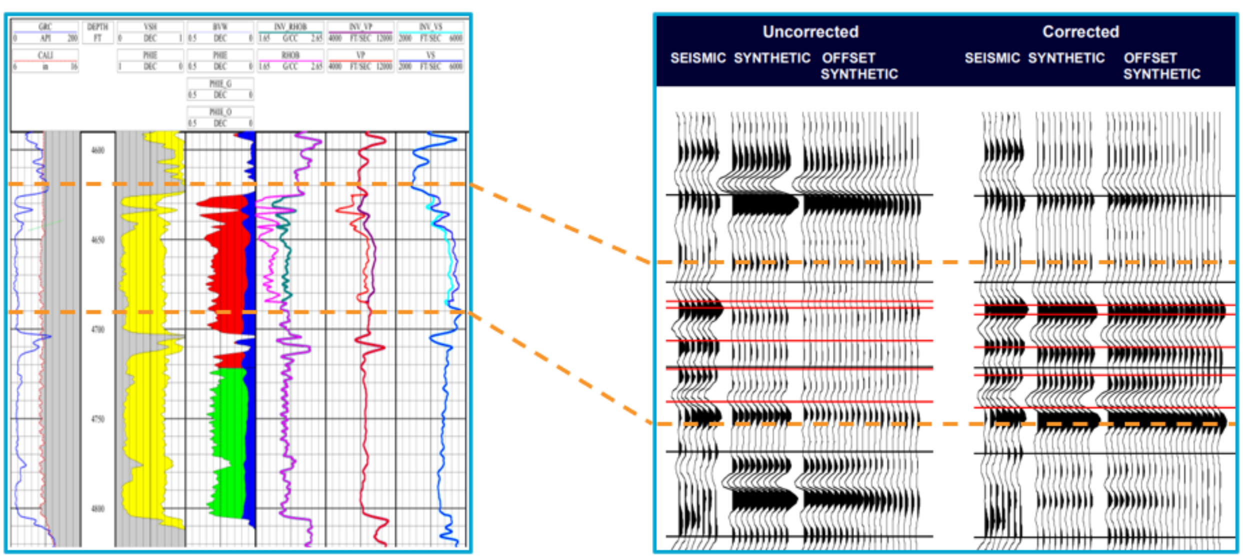

Figure 2. *Mud invasion correction of log data (left). Uncorrected and corrected synthetic trace and gather comparison with seismic (right), adapted from Walls et al., 2004.*

Workflow

As with any valuable workflow, the quality control process increases the likelihood of success and reliability of the results. Logs often have many versions and different qualities relating to the acquisition, calibration history, and depth/target ranges. Visually examining your data prior to working with it helps to identify common issues that need attention and ideally reduce unnecessary iterations. Comparing logs to one another helps to diagnose meaningful relationships and indicated when logs are calculated instead of measured. Broadly, the steps involved in the seismic analysis of well data include:

1. Examining well logs
2. Editing and calibrating logs
3. Creating and calibrating seismograms

These fundamentals can be built upon to model noise, frequencies, and multiples, which if not considered, often limit the correlation potential in well-to-seismic ties. We can also assess the feasibility of using seismic to delineate reservoir properties with AVO(A) analysis.

Conclusions

Seismic analysis of well data can provide useful information about how we can leverage seismic data to predict lithology and fluid distribution away from wells. By examining, editing and calibrating log data, we can enhance the correlation to seismic and improve our understanding of the geologic significance of the elastic properties of the reservoir. Other uses include informing geoscientists of the required data quality, in terms of noise, multiples, or other harmful aspects which may help guide conversations when planning future acquisition and processing projects.

References

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