D04

High Resolution 4D Inversion Driven by Dynamic Constraint

P. Thore* (Total E&P UK Limited)

SUMMARY

In this paper I present different cases where the use of prior geological and dynamic information has enhanced the resolution of 4D seismic inversion and conducted to high quality results which can be used during Assisted History Matching.
The prior information introduced in the 4D inversion (the predefined number of layers and the possible range of expected saturations) leaves freedom to 4D inversion to extract more information from the seismic data. It just compensates its ontological weaknesses.

Multi-disciplinary work requires trust, common vocabulary and data exchange. In addition, a minimal understanding of limitations inherent to each discipline is needed to develop and implement trans-disciplinary constraints. Indeed, overall efficiency will be reached by imposing constraints that compensate weaknesses of a discipline by strengths of others rather than by relying on a universal and phantasmagorical big loop.

Seismic strength lay in lateral resolution and simply in the volume of seismic data which overwhelms other disciplines. Seismic main weaknesses are its limited vertical resolution and its difficulty to differentiate pressure from saturation effects. Geology strengths rely in its theoretical concepts and in its ability to define directional and particularly vertical trends. Geology main weakness originates in the difficulty in identifying and using analogues and quantifying geological variables; practically, proportion bias is frequent. Reservoir engineering strength lay in the existence of well established physical laws that provide an ability to quantify global proportions and spatial trends. Reservoir engineering data is limited in quantity, is of heterogeneous nature, and always display poor spatial coverage.

In this paper I present different cases where the use of prior geological and dynamic information has enhanced the resolution of 4D seismic inversion and conducted to high quality results which can be used during Assisted History Matching.
One of the techniques that we use for seismic inversion is closed to the super-resolution algorithms. Instead of introducing the sparseness of reflection coefficients which is the constraint that is used in 3D inversion, in 4D, we can fix the number of layers. This information can easily be obtained from geological and dynamic considerations. By this mean we weaken the limitation due to the limited seismic bandwidth and we are able to resolve thin layers far beyond the Rayleigh criterion ($\lambda/4$).
Our inversion also takes advantage of dynamical prior knowledge on possible repartition of saturations that can be obtained from dynamic simulations especially in the swept area. This information is transformed into possible repartition of elastic parameters (density, P_velocity and S_velocity) using a rock physics model and introduced in the 4D inversion as a constraint. The constraint does not act on the absolute magnitude of the changes of elastic parameters but rather on their relative magnitude (i.e. the ratios of the changes of density versus P_velocity and P_velocity versus S_velocity). This constraint considerably stabilized the 4D pre-stack inversion and produces results that are suited for further Pressure and Saturation inversion.
The prior information introduced in the 4D inversion (the predefined number of layers and the possible range of expected saturations) leaves freedom to 4D inversion to extract more information from the seismic data. It just compensates its ontological weaknesses.