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Iterative update of absolute simultaneous inversion for optimal lithology prediction.

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Introduction

Low frequency models (LFMs) can make or break an absolute inversion project. The models provide elastic property information over low frequencies missing from the seismic bandwidth. Absolute inversion results are guided by LFMs and supplemented with information from seismic. LFMs can therefore have considerable influence on results and interpretations. Care needs to be taken in building LFMs to ensure that the models do not bias inverted reflectivity. LFMs need to be representative of geology (structure and stratigraphy) and of lithology or fluid occurrence and distribution. The background models need to be guided by available data while enabling seismic AVA to control interpretations of the inversion results.

Data for LFMs typically comprise elastic logs, rock physics end-member trends, seismic velocity, horizon and fault interpretations, stratigraphic layering schemes and geobodies. LFMs are stable, long wavelength background property trends which honour well control. Different LFM building strategies exist. These range from simple depth-dependent variations derived from rock physics trends or seismic velocity, to complex models characterised by well log extrapolation within a structural framework and guided by one or more properties (e.g. seismic velocity, rock physics trends and/or geobodies).

The efficacy of the LFM depends upon algorithms, data, geology and workflow. Extrapolation of elastic logs is subject to the mathematical algorithm used and may not be representative of geological variations. Structural or sedimentological complexities may result in non-optimal horizon interpretations and layer definitions. These may be unsuitable for guiding the propagation of low frequency information across the volume. If a lithology layer is thick (greater than half the dominant wavelength of the propagating wavefield) it will have a significant low frequency component. It is also likely that the layer changes thickness within the study area. In this case, it is important to include the 3D morphology of the layer in defining the distribution of the associated low frequencies in the LFM.

We present the results of an iterative method to update the LFM and absolute simultaneous inversion that progressively includes the low frequency characteristics of deltaic reservoir sands of varying thickness (10 to 150 m). The workflow enabled optimal lithology characterisation while negating any bias, in the LFMs and inversion results, from the extrapolation of well log properties using limited horizon interpretations.

Workflow and results

Elastic logs were edited for use in building baseline LFMs: sandstone properties were replaced by rock physics end-member property trends for claystones. Baseline LFMs were built using the edited elastic logs, the rock physics claystone trends and seismic velocities. A best-fit polynomial equation was used to relate the rock physics trends and seismic velocities to the logs across multiple wells. The logs were not kriged into the model. The LFMs were used in a baseline absolute simultaneous inversion. P-impedance and Vp/Vs results from inversion were interpreted in conjunction with a regional rock physics model to derive initial lithology probability volumes. The sandstone probability volume was used to update the baseline LFMs with mixtures of sandstone and claystone rock physics trends in proportion to the value of sand probability. The low-frequency components of the updated models were used to re-run the simultaneous inversion and the lithology interpretation. The workflow was repeated (Figures 1 and 2) until convergence - i.e. showed negligible differences between subsequent iterations.

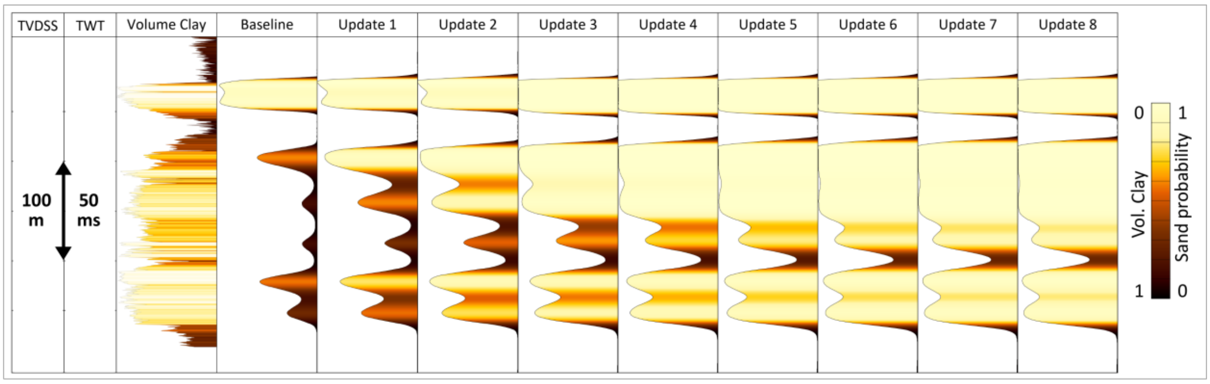

Figure 1. A volume of clay (Vclay) log compared against sand probability from successive iterations of absolute simultaneous inversion. The results have stabilised at Update 6 with subsequent iterations displaying only minor differences.

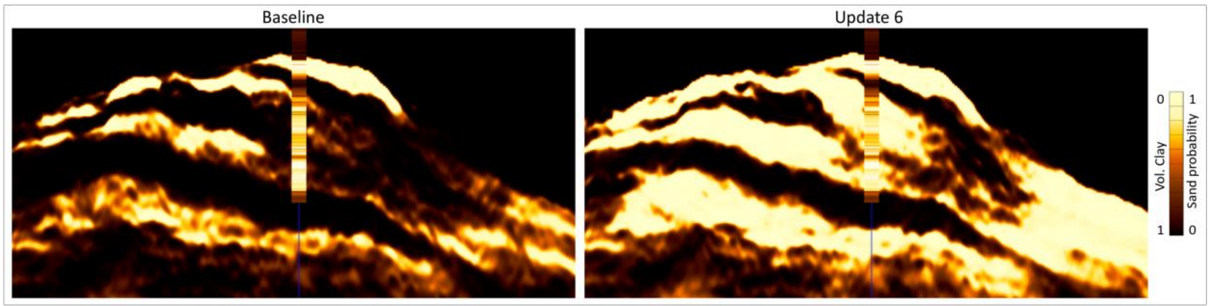

Figure 2. Section view comparison of sand probability from Baseline and Update 6 of the absolute simultaneous inversion. The results are overlain by the Vclay log at a well location.

Conclusion

Starting from a background shale LFM, each iteration of absolute simultaneous inversion has provided the means of updating the LFM by incorporating 3D distributions of reservoir properties. The result is a data-driven interpretation of reservoir distribution that reduces the potential bias of LFM building workflows.

Acknowledgements

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