

Mapping horizons leads to greater exploration success

Horizons play an important part in inversion and interpretation.

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Seismic inversion has played a key role in seismic interpretation for more than 35 years, and it remains central to oil and gas exploration success today, generating accurate rock property estimations and realistic geologic models of the reservoir.

Yet whether it is prestack, poststack, or simultaneous inversion, the success of seismic inversion is fundamentally dependent on the interpreter's model-building tools and whether the initial models are consistent with seismic measurements and honor the structural details within the reservoir.

So how are seismic interpreters faring today in creating these models for the seismic inversion process? The answer is mixed. While there is no doubt that seismic interpretation has made a number of significant advances over the last few years, geological models still remain highly generalized, with interpreters unable to gain a clear picture of the depositional history from the seismic data.

Many seismic interpreters, however, are missing a trick – the crucial role of horizons in seismic interpretation and seismic inversion. Horizons always have been an important element of seismic interpretation but rarely have been used to their full potential. Typically, a limited number of horizons tend to be mapped, leading to an oversimplified geological model.

Accurate and denser seismic horizon tracking can enable interpreters to see more geology by slicing through the data in a geologically sound way. It also can guide well correlations, generate better insight into the depositional environment and the area's depositional history, and improve the chances of finding stratigraphic traps.

Additionally, it can result in automatic fault detection and definition, the accurate structural modeling of both fields and prospects, and a much more robust geological model being put forward for seismic inversion.

Horizon interpretation

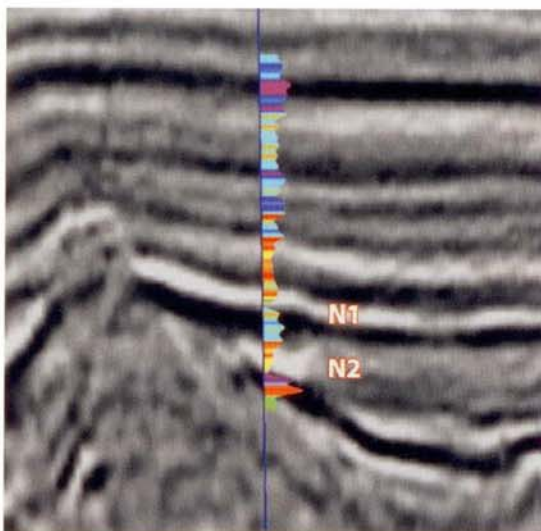
Against this backdrop, dGB Earth Sciences has developed the HorizonCube. By interpolating well data along the dense set of horizons, interpreters can generate detailed low-frequency geologic models that are consistent with seismic measurements and improve seismic inversions.

The system is a dense set of auto-tracked, correlated 3-D stratigraphic surfaces, with each horizon representing a relative geologic timeline. The model is built by inputting a steering cube containing local seismic dips, at least two mapped horizons, and optionally mapped fault planes. The advanced algorithms then create a set of continuous, chronologically consistent horizons.

Framework horizons are mapped with a conventional amplitude or dip-steered auto-tracker. The advantages of the dip-steered tracker are the speed and the tracker's greater awareness of faults. By automatically stopping

against mapped fault planes, for example, horizons with watertight intersections at the faults can be generated.

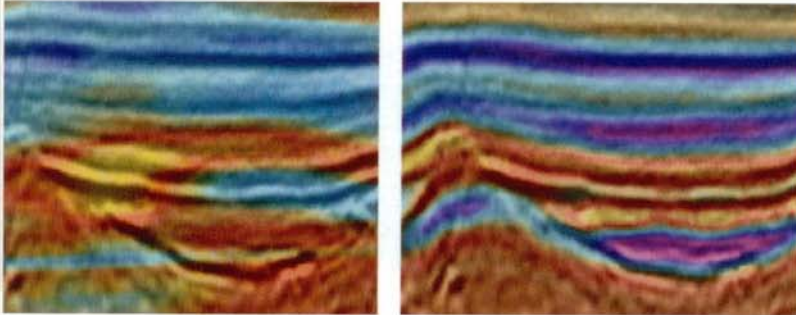
The dip-steered auto-tracker allows noise to be removed from the dip fields to enable the user to control the detail that needs to be captured by the horizon tracker. The smoothed dip fields on which the dip-steered auto-tracker operates are more continuous than amplitude fields tracked by conventional auto-trackers, which generally produce patchy horizons. More geology is extracted from the 3-D seismic, and highly detailed and accurate low-frequency models are put forward for acoustic impedance and elastic impedance inversion.



Impedance was applied to this seismic section. The low P-impedance observed from Well log A, indicated by the N1 and N2 labels, illuminates the target sandstones under investigation. (Images courtesy of dGB Earth Sciences)

Offshore Brazil

Operator OGX has incorporated HorizonCube into its workflow to reduce exploration risk by applying high-resolution inversion and HorizonCube to a prospect delineation study offshore Brazil.



A comparison of the IP background model before (left) and after (right) HorizonCube shows a much better consistency with the geologic structures.

The main targets were oil sandstones associated with the compressional (P)-impedance variation observed at the well log. A number of volcanic cones in the area condition the geometry and continuity of sandstone bodies. Prior to this study, one exploration well had been drilled in the area (Well A), reaching an oil-filled reservoir. Original amplitude data indicated large lateral continuity of the reservoir layer. The objective was to delineate the oil-saturated zone of the sand body.

Well A was used as input for the inversion in the prestack data. The N1 and N2 reservoirs were the target sandstones under investigation. Rock physics analysis using P-impedance and shear (S)-impedance showed good separation between the oil-saturated sands and water sands, meaning that, with accurate inversion results, the desired objective could be achieved.

The first task was to improve the quality of the seismic information through the preconditioning of the seismic common reflection point gathers. Next, HorizonCube was used to extrapolate the P-impedance and S-impedance logs to create a stratigraphically consistent low-frequency model incorporating the inversion workflow.

Comparing the results with the previous inversion, interpreters could clearly see the benefits of incorporating the HorizonCube into the inversion workflow. The increased resolution obtained from the inversion made it possible to correctly map the reservoir thickness and its lateral extension. The improvement of the correlation coefficient

between well logs and the inversion results, from the initial inversion to the final deliverable, gave the team confidence to proceed in generating fluid indicators.

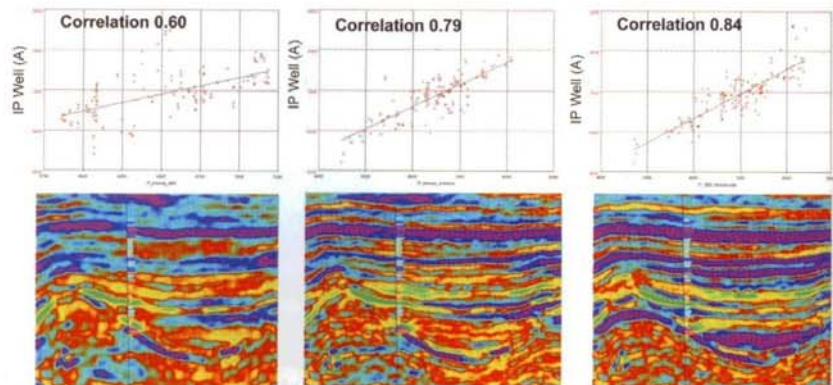
A volume of P-wave impedance (IP) minus α *shear wave impedance (IS) was derived (where α is a constant calibrated with well data to cancel lithological influence), enabling the illumination of both levels of the reservoir. It was possible to greatly improve the quality of the estimation of the subsurface parameters using the results obtained with high-resolution inversion and incorporating a stratigraphically consistent low-frequency model. The results showed that accurate seismic inversion is a key tool for prospect risk reduction as it can indicate changes in the elastic properties of the subsurface due to fluid variation.

dGB currently is developing software that combines forward modeling, rock physics, and inversion into a single package. With the new software plug-in, simple wedge models can be generated to help understand the seismic response of the interval of interest, and more complex stochastic simulations can open the way to more advanced reservoir characterization workflows.

While conventional interpretation workflows might only require a limited number of key horizons to be mapped, by automating horizon tracking and creating a denser set of horizons, interpreters can extract more geology from their seismic data. The result will be improved seismic inversion, a better targeting of fields and prospects, and increased oil and gas exploration success. **ESP**

Acknowledgments

The authors would like to thank OGX for permission to publish these results, especially Marcos do Amaral for his innovative thinking and his willingness to always incorporate leading-edge technologies to solve exploration challenges.



From left to right are shown P-impedance obtained from prestack data and the original background model, P-impedance from preconditioned data and the original background model, and P-impedance with preconditioned data and the HorizonCube-derived background model.