# Prestack Inversion Fundamentals: Practical Considerations for Success

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## Summary

Inversion is a process that predicts certain layer properties of the earth using seismic data. This is obviously a very useful objective and could be considered one of the main reasons we acquire seismic data. There are many types of inversion and a wide range of subjectivity involved in executing each method. Prestack inversion is perhaps the most sophisticated of the methods, but it requires careful conditioning of zone-specific well log data and seismic data. Reliance on subjective assessments of the quality and success of this conditioning, plus appropriate choices of relevant zones, geological constraints and key parameter selection means that there are many pitfalls and opportunities for error. This presentation will describe the objectives and expectations of inversion in the context of common methods, criteria for success and sensitivity to data, parameters, judgments and choices.

## Method

All inversions are models of the earth, with the stipulation that, when convolved with a wavelet, the resulting synthetic seismic data matches the real seismic data (Figure 1).

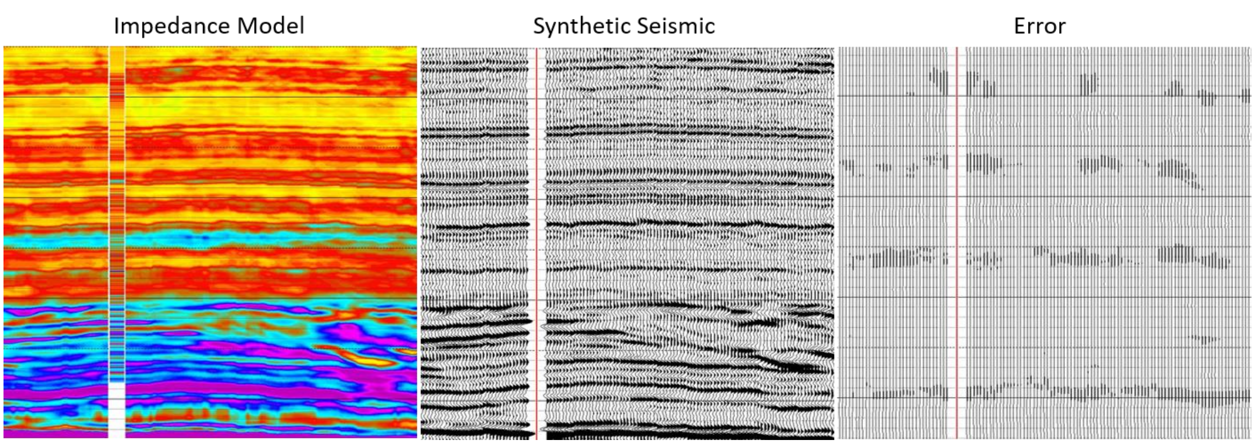


*Figure 1: Poststack inversion model (left), the resulting synthetic seismic after convolution with a wavelet (center), and the residual error between the real seismic and synthetic seismic (right).*

Poststack inversion requires a match with poststack data; prestack inversion requires a match with prestack data. This might sound simple, but given the noise, processing artifacts and resolution of real seismic data, combined with uncertainty in wavelet estimation, combined with non-uniqueness and bias of model elements, combined with tolerance levels for residual error (between the real and synthetic seismic traces), the entire process is anything but. It is iterative from many perspectives, which can make it time-consuming, as well as uncertain when multiple possible answers are generated. Clients can be forgiven for being skeptical of a process that takes a long time and results in uncertain solutions. With careful oversight and foresight however, confident results can be obtained and utilized in subsequent geological predictions and decision-making.

Seismic data conditioning starts with processing and, particularly in prestack inversion, which requires a match with prestack data, noise attenuation, residual moveout, relative amplitude preservation, multiple attenuation and prestack migration are all important first steps, that occur even before the inversion gets started. Conditioning of well log data is equally important since the initial models generally rely heavily on well log guidance. Log quality assessment of P-wave sonic, S-wave sonic and density curves provide confidence in quantitative values and trends that constrain the model, and the basic well-tie that matches well data in depth to seismic data in time is essential to initial alignment of properties.

Model-building is an art in itself. The initial model must be determined by the inversion practitioner. Updates to the model thereafter are done by the iterative mathematical error-reduction algorithm, but the ultimate results are very dependent on the initial starting point. Some considerations for making a good model include good quality layer boundaries (seismic horizons), appropriate frequency content (complimentary to the frequency content of the seismic data), realistic interpolation between wells and horizons, appropriate selection of wells (usually not all wells), and, of course, reliable depth-time conversions (well ties). Figure 2 illustrates the effect of two different inter-horizon geometry assumptions in an initial model that could potentially have significant effects on the resulting inversion. Inversion, therefore, requires not only geophysical knowledge, but an adequate understanding of petrophysics, geology and geological relationships.

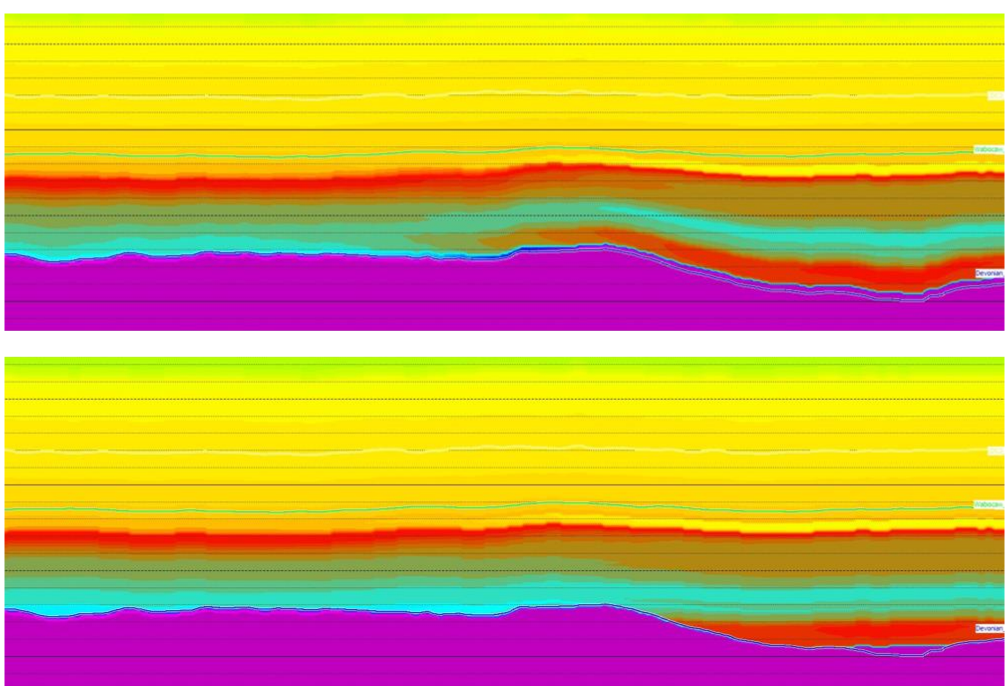

*Figure 2: Initial model examples showing a conformable inter-horizon assumption (top) compared with a base-lap assumption (bottom).*

## Conclusions

The inversion process is much more complicated than it seems, with the potential for significant uncertainty introduced by bias and subjective influence. Both bias and subjectivity are, however, essential components of a successful inversion. This may appear contradictory, but this circular relationship can be managed and in fact drive the ultimate successful integration between processor, inversion analyst, petrophysicist, interpreter and geoscience team. A confident prediction of the earth for more accurate and efficient subsequent decisions is worth the effort.

## Acknowledgements

There are many geoscientists who have studied, improved and provided inversion algorithms to the community, but I would like to particularly acknowledge Dan Hampson and Brian Russell who have been instrumental and inspirational to my own inversion journey.