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Construction Technique Of High Resolution Velocity Field - New Attribute For Seismic Interpretation

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Summary

In this work, we propose a technique for High-Resolution Velocity construction based on Amplitude Inversion combined with Dynamic Auto Correlation or Dynamic Time Warping. The main aim for this workflow is to provide a High-Resolution velocity field that can be used as an attribute in data interpretation and classification. Synthetic examples show that the algorithm can reconstruct the P-wave velocities from log data in the case of no anisotropy. We demonstrate cases of constructed velocity field's implementations for lithology, pore pressure and reservoir highlighting. Taking into account that technique does not require big computation resources, that makes it a convenient seismic interpretation attribute.

Introduction

Seismic velocities are valuable information that most of the time is not fully exploited in exploration work. Our aim is to construct accurate velocity fields for seismic data processing, AVO gradients, depth conversions, imaging processing, and we use one of these fields, e.g. when translating seismic velocities to pore pressure. In more seldom cases, we use velocity for quantitative analysis like lithology (Hubred J.H. & Meisingset I., 2013) and fluid predictions, which are important for exploration.

Velocity resolution greatly influences exploration predictions. To reduce uncertainties, we integrate logs data to seismic velocity. When well logs are not available, we are limited by stacking velocity field. Advanced velocity computation methods with higher resolution, e.g. FWI, require more time and resources. Thus, it is necessary to develop a convenient algorithm, which increase certainties. We propose a High-Resolution Velocity estimation algorithm that can be used to predict possible reservoirs, lithology and geohazard situations.

High-resolution velocity constriction principle

Traditionally, seismic velocities have been estimated from semblance analyses (kinematic method). The analyses can be done manually or automatically. The velocity field generated by such methods can be used for further seismic data processing; however, it lacks resolution for lithology and fluid predictions.

Relative velocities can be estimated from seismic amplitudes (dynamic methods) with higher resolution. The amplitude response is a function of both seismic velocities and rock density. Therefore, in order to separate the velocity response from the dynamic amplitude method, it is necessary to calculate a higher resolution kinematic velocity field.

We calculate a high-resolution kinematic velocity, based on the estimation of time differences between the different traces of CDP gathers directly. To calculate time differences, we can use Dynamic Auto Correlation or Dynamic Time Warping methods (Sakoe, H. & S. Chiba, 1978 and Silva D. & Batista G.E.A.P.A, 2015). By using both kinematic and dynamic methods, we can estimate a velocity field with higher resolution than achieved by a semblance-based approach (Figure 1). A predicted velocity field is close to P-wave velocity (Figure 2). Thus, in areas where no wells exist, we can estimate a pseudo P-wave velocity field prior to drilling.

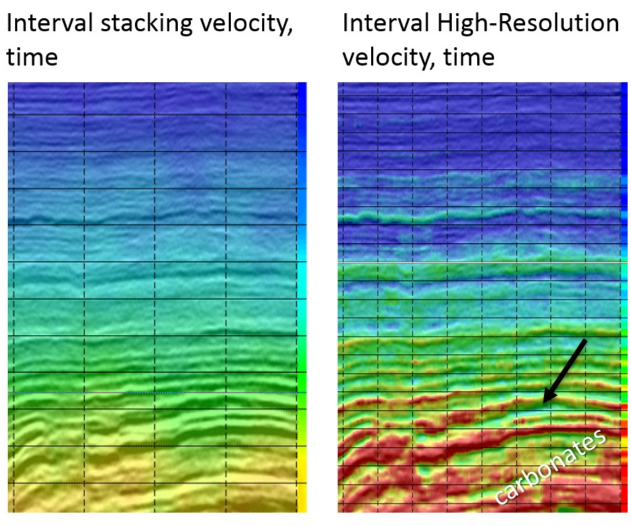

***Figure 1** Comparison of stacking (left) and High-Resolution (right) interval velocities. Black arrow points to sandstone gas field on the top of carbonate layers.*

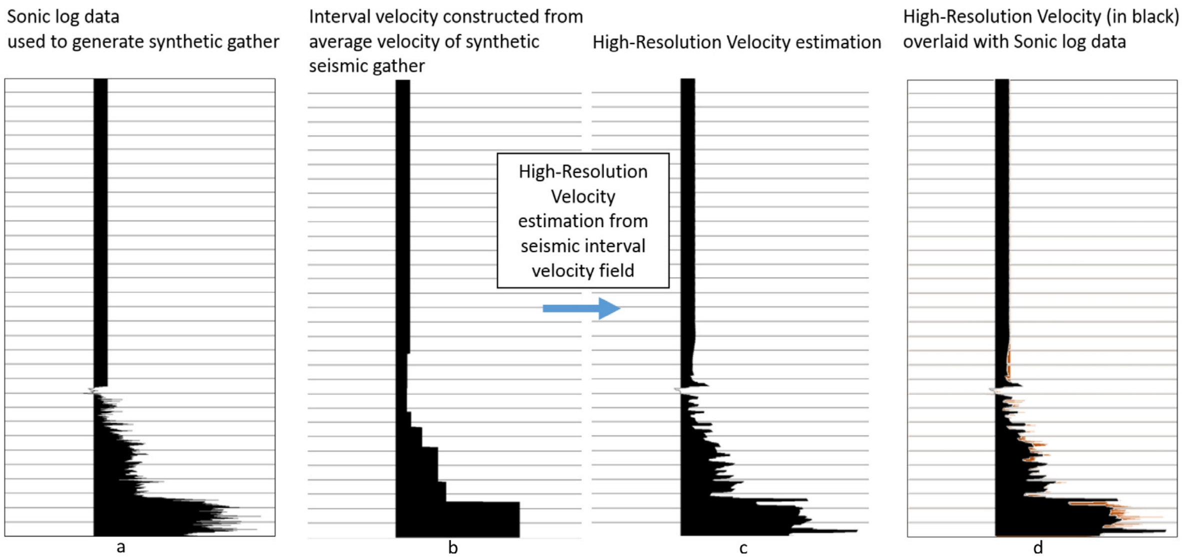

Figure 2 *High-Resolution velocity calculation using synthetic data. Well logs data is used to generate synthetic gather. Picture (a) shows Sonic log. The synthetic gather was inverse NMO corrected, and a new NMO velocity function was handpicked, like for real seismic. Picture (b) illustrates interval velocity of the picked function. High-Resolution velocity (c) is estimated by the suggested technique described in this abstract. Picture (d) shows comparison of the Sonic log data (brown) measured from the well and the estimated High-Resolution velocity (black).*

Examples of High-Resolution velocity field's implementation for seismic interpretation

High-resolution velocity calculation technique provides more accurate velocity estimation. It allows tracking low and high velocity layers corresponding to different geological structures. In addition, it helps to estimate lithology and overpressure zones more accurate (Figure 3). Selecting appropriate color code helps to differentiate lithologies and to find zones with velocity drop in a layer, which may be associated with hydrocarbons presence. Figure 4 illustrates the advantage of High-Resolution velocity field's implementation for seismic interpretation, particular in lithology prediction, over stacking velocity fields.

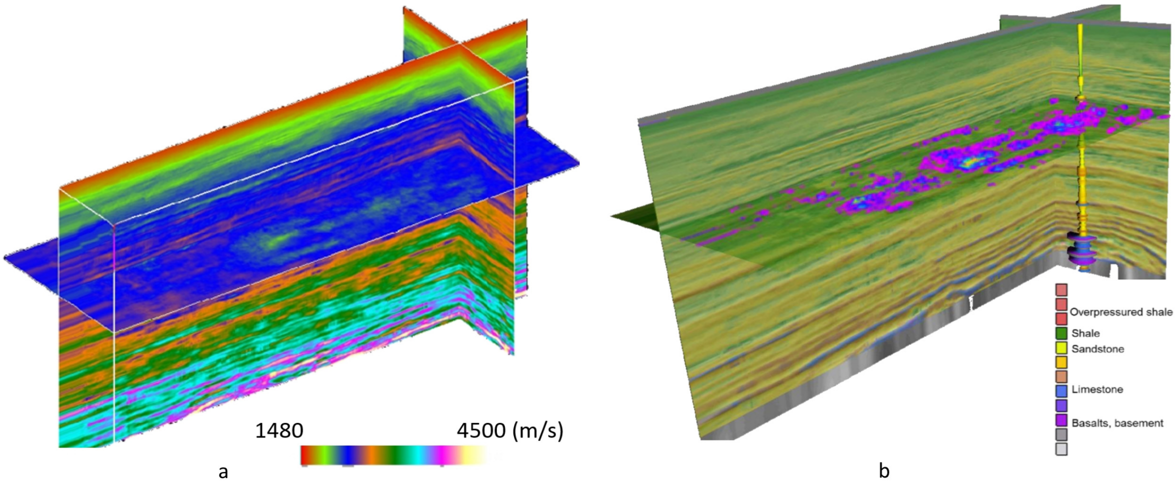

Figure 3 *High-Resolution velocity field with constant time slice though the shale layer with overpressure zones (a), and its implementation for lithology calculation and pore pressure prediction (b).*

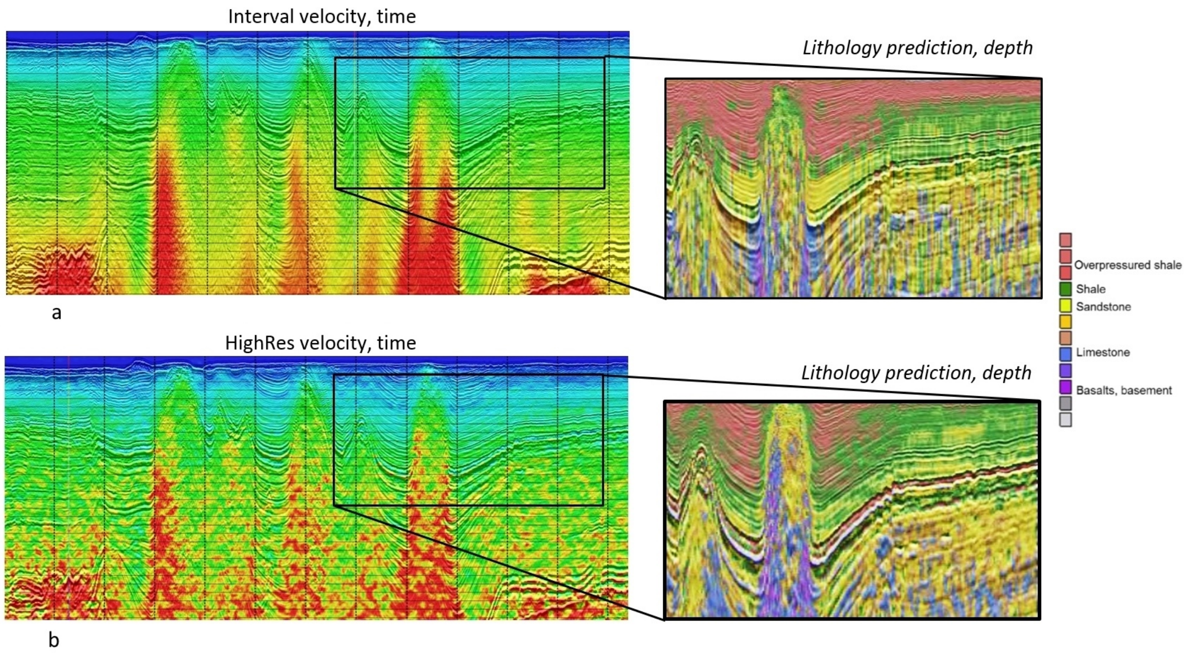

Figure 4 *Comparison of seismic interval and High-Resolution interval velocities implementations for seismic interpretation, particular for lithology prediction.*
(a) - right picture is interval velocity with seismic overlaid (in time); left picture is zoom of the seismic section (in depth) with lithology prediction overlaid.
(b) - right picture is High-Resolution velocity section with seismic overlaid (in time); left picture is zoom of the seismic section (in depth) with lithology prediction overlaid.

Conclusion

We developed a processing flow for High-Resolution Velocity construction based on two methods: Amplitude Inversion combined with Dynamic Auto Correlation or combined with Dynamic Time Warping. By combining these two methods, High-Resolution Velocity field can be generated quickly, without big machine computation power. We showed that implementation of High-Resolution velocity field is a useful attribute for seismic interpretation: lithology, geohazard and fluid prediction.

Acknowledgements

The authors want to thank Chevron Norge, TGS for data permission providing, and First Geo for permission to publish illustrations with lithology predicted sections.

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