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Correction for Shallow High-velocity Anomalies. 3D Seismic Survey Case Study from Poland

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SUMMARY

High-velocity anomalies in the near surface can significantly degrade the quality of the seismic data causing e.g. a discontinuity in horizons and a false pull-up. The authors are presenting the method that had proven to be very effective and efficient in terms of time and costs. In shown case the concept of a special approach to seismic static corrections brought much better final results than pre-stack depth migration or pre-stack wave equation datuming. Presented case study showed significant improvements in comparison to traditional statics corrections in terms of reliability of structural time image alike continuity of the reflection events.

Introduction

This paper presents a special approach to seismic data processing in a region where near surface anomalies occur with their huge influence on processed seismic image.
Presented case study comes from Polish region near Poznan city. The regional geological structure in the area is monocline whereas the main target of seismic exploration is the Zechstein and Rotliegendes formations (middle Permian). Since the structures in those formations are in general of small amplitudes therefore any time errors must be minimized as much as possible.

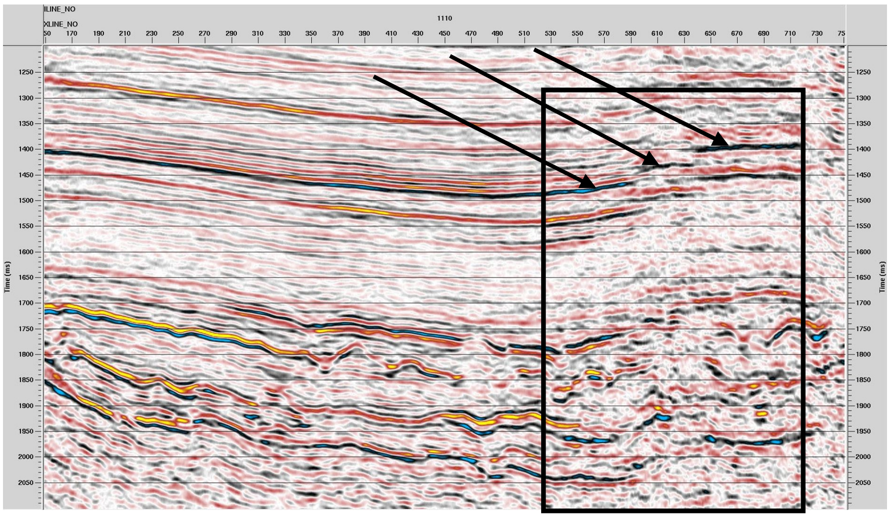


Figure 1 *Seismic section shows problem with discontinuity in horizons connected with high-velocity anomalies impact.*

A discontinuity in horizons (marked with arrows in Figure 1) and a false pull-up are caused by strong, high-velocity anomalies occurring in subsurface layers (600- 800 m below surface). The anomalies are connected with a conversion of marly-siltstone facies into carbonate facies (the Middle Oxfordian deposits). This type of image cannot be accepted because of poor quality of seismic horizons in Zechstein formations, but main problem is lack of possibility to get true structural image in depth (parameters of high-velocity anomaly are unknown).
The case study presents how seismic static corrections were estimated to compensate impact of high-velocity anomaly and eventually, how authors were able to manage this subsurface problem.

Analysis of influence of subsurface high-velocity anomaly on seismic signal

An analysis of influence in case of high-velocity anomaly on deeper horizons is schematically shown below (Figure 2).

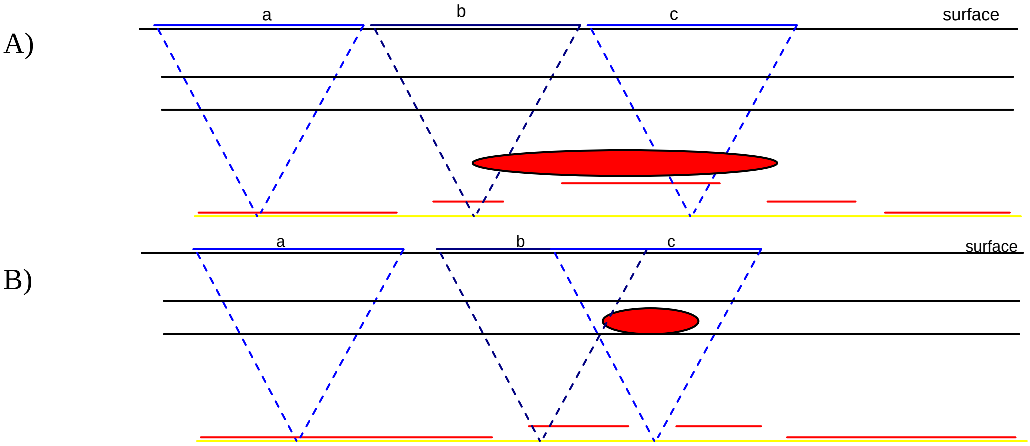


Figure 2 *Subsurface high-velocity anomaly modeling.*

Red color horizons with visible discontinuity and decreasing quality in some part of area correspond to seismic signal measured at the farthest offset. Diagram (Figure 2A) shows areas out of anomaly range (a), high velocity anomaly is partially taken into consideration (b) and full anomaly taken into consideration (c). When anomaly is small (Figure 2B) (smaller than the length of spread) than parts of horizons that are broken apart look differently.
The extent between broken down parts of horizons (or seismic signal ambiguity), depends on such factors as available maximum offset measurement in the spread, anomaly zone shape or degree of ground roll removal.
Pre-stack depth migration should give good solution in this case. Unfortunately, complicated structure and the depth of this shallow anomaly have had huge negative influence on correctness of such attempt. For the same reasons we cannot expect favorable results of pre-stack wave equation datuming.
Therefore authors present another solution of this problem.
From "brute stack" seismic section without time compensation, it is not too much difficult to define a range of high-velocity anomalies. Figure 3 shows how large is the area of high-velocity anomaly (red color marked). In this case it is about 1000 sq km. The velocity of the main formation ranges from 2800-3000 m/s in the region without an anomaly, whereas velocities of 4200-4500 m/s are characteristic for anomaly areas with thickness of 120-300 meters.

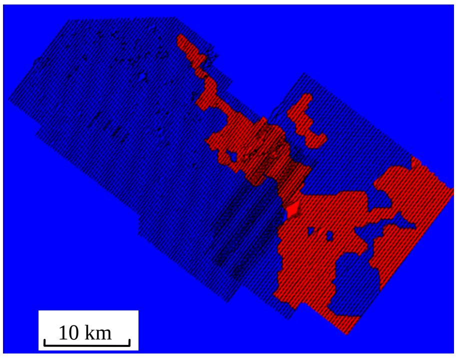


***Figure 3** Area of high-velocity anomalies (red color marked).*

Method which takes advantage of information from first breaks

First break picks were used to calculate static corrections having in mind subsurface anomaly parameters.

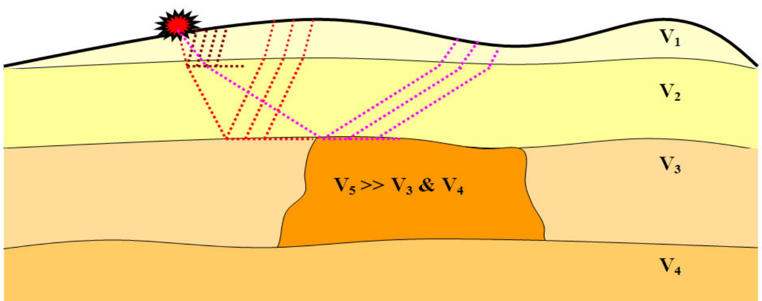
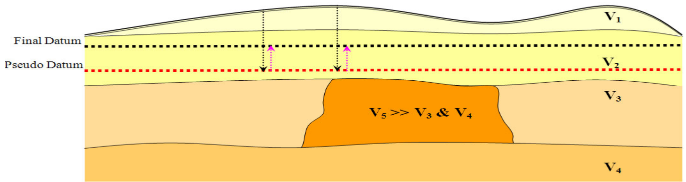
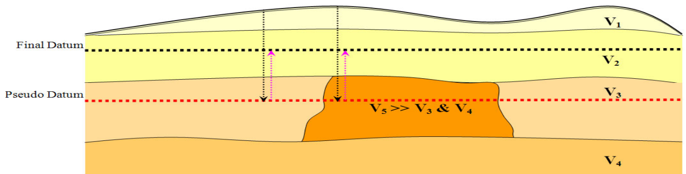


***Figure 4** Schematic picture shows refracted rays in high-velocity anomaly survey.*

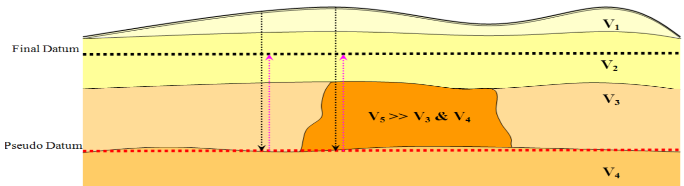
In the given conditions, depth range of measurement for such method was maximum 800 m below surface. If it is possible to define entire shape of anomalies (refraction wave from layer below anomaly), problem of deformation could be easily resolved. Unfortunately usually it is impossible to do so. When full anomaly cannot be observed, because there is no information about bottom part of the layer with anomaly, solution of this problem can include only information about top part of the layer and its velocity. Using deep pseudo-datum during computation of static corrections allows to compensate for this anomaly.



No anomaly compensation.



Partial anomaly compensation.



Full anomaly compensation.

Figure 5 *Schematic picture of shallow high-velocity anomalies model with different pseudo-datum level.*

The method based on refraction static corrections is successful only when bottom part of anomaly is flat (or nearly flat). Otherwise, when there is a slope - compensation by static corrections can be partial only.

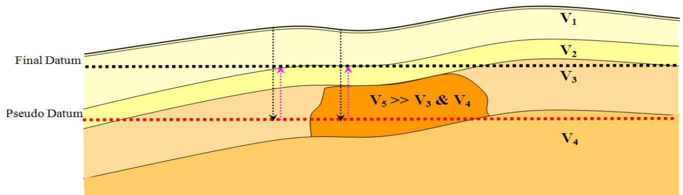


Figure 6 *Schematic picture of partial anomaly compensation due to layer deeping.*

Additional manual correction of anomaly

In case of partial anomaly compensation we have to complete method by applying additional time corrections. Values of additional corrections could be defined by analyzing seismic time sections.
Time corrections are defined as difference between expected and observed two way times for horizons which are considered to be stable.
Compensation corrections from CDP domain are converted (projected) into static corrections in source and receiver domain.
If there is no possibility to fully or even partially compensate for the anomaly by refraction, or modeled statics, then this way of correction becomes the basic one.

Automatic static corrections

Remaining part of corrections could be done by iterations of Autostatic Residual Corrections (with large maximum shifts allowed) and time correction variation which come from high-velocity anomaly could be compensated by time-variant „External Model Trim Statics”.

Conclusions

Presented method allowed authors to achieve consistent seismic section for the whole region with compensation in places where high-velocity anomaly occurred. Much better efficiency of compensation has been achieved for the 3D survey rather than the 2D one. Differences come from better efficiency of refraction statics calculation, automatic statics correction software, and also from time correction coming from „External Model Trim Statics". Methodology presented in this paper allowed to obtain correct material faster and cheaper.
Time sections in Figure 7 show comparison between standard processing without high-velocity anomalies correction and processing with anomaly corrections.

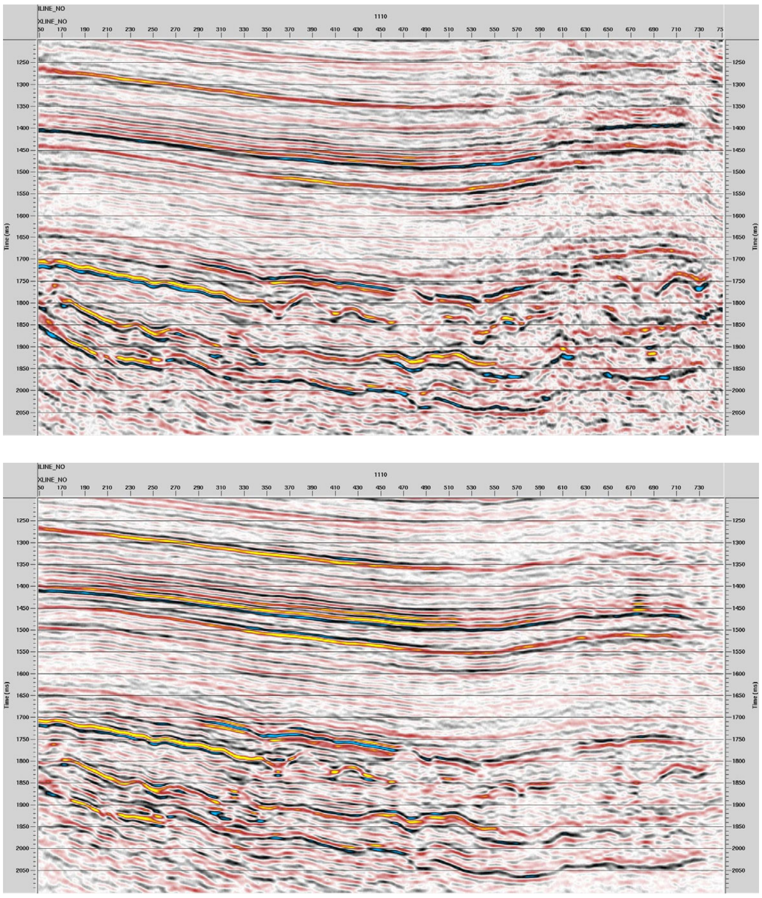


Figure 7 *Seismic section without correction (top) and section after applying high-velocity anomaly compensation (bottom).*

Acknowledgments

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