Tomographic Inversion Solutions in Foothills Areas

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Summary

Land surveys may suffer heavily from the effects of near surface anomalies. In particular, in the foothills areas, weathering, limestone outcrops, and rapid changes in elevation may cause virtually all the problems associated with the data. Here we present a methodology to address statics problems on 2D and 3D projects coming from near surface anomalies: a tomographic solution which incorporates turning-ray tomography into its inversion engine.

Introduction

Recently several 2D lines and a 3D survey were re-processed with the aim of achieving a good quality statics solution to produce a better image with respect to previous processing attempts. These data had known problems due to foothills areas such as rapid changes of elevation and surface conditions. The elevations vary by 200 to 300m. At the start of the project it was clear that one of the major challenges and keys to success would be to have a good statics solution. What would make a good statics solution for these data sets?. A homogenous statics solution for all the areas of of the surveys was desirable if possible.

There are various ways to address this challenge. In the 2006 CSPG-CSEG-CWLS Joint convention, Todd Mojesky's poster session discussed Weathering (Refraction, Tomographic and Surface Modeling Methods) and Reflection solutions from an algorithmical and methodological point of view.

As usual in the Canadian foothills, there were no upholes to be used within the projects for a modeled solution, so, of course, a first-arrival based solution would be required. One of the main advantages of this option was the ability to sample the near-surface at every source and receiver and solve for short and medium wavelength statics.. The use of first break data gave us an opportunity to use our newest tomographic inversion engine, Geostar, to address severe topography and large horizontal velocity gradients. A good statics solution may improve the image of seismic data but that doesn't necessarily make an accurate weathering model. QC of a near-surface model therefore involves questions concerning its "believability" relative to the implied geology, and how well it conforms to any available geological surface maps. *[In this workshop, we'd like to bring this to the table and audience for a full discussion.]*

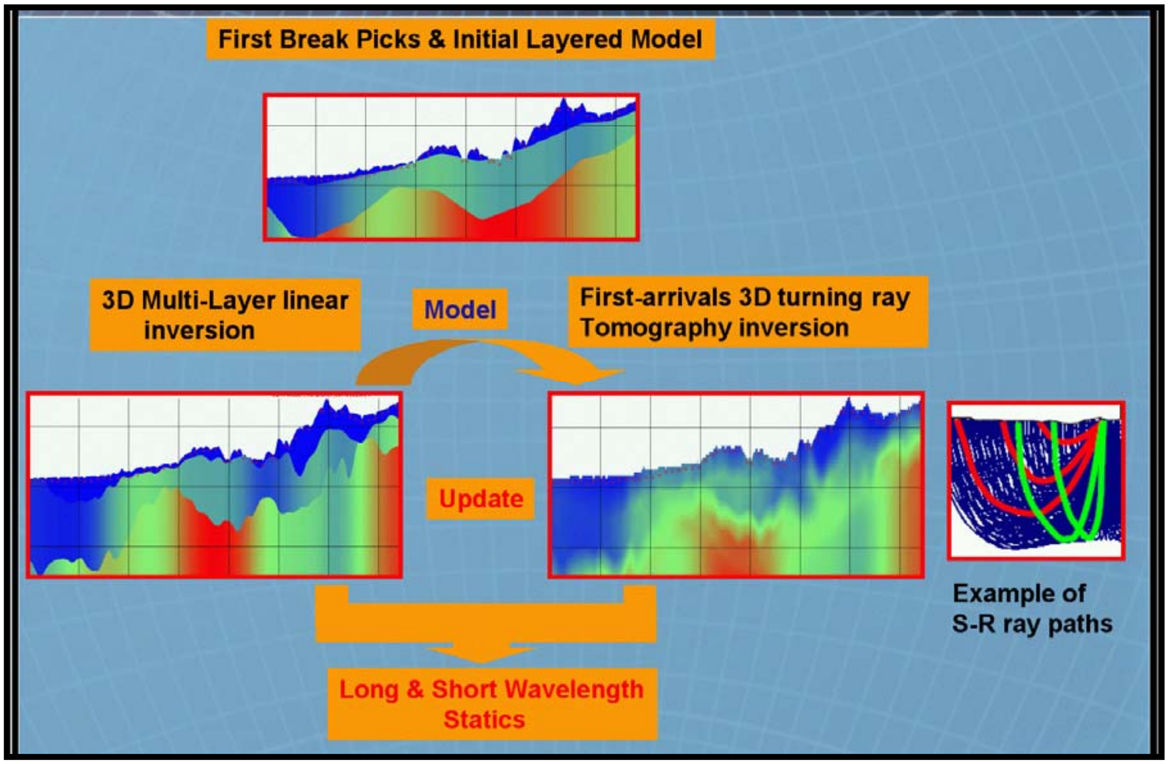


Figure 1. Grid Tomography

Tomographic Methods

The input model used for tomography is either the simple initial model or, more typically, the model from a linear inversion (refraction) solution. It incorporates turning-ray tomography into its inversion engine. The near surface medium is divided into cells (grids), and a velocity is inverted uniquely to populate the cells at each location. One advantage here is that the grid model can represent vertical velocity gradients and velocity inversions.

The methodology is similar in concept to a PSDM depth inversion (Figure1). These methods essentially try to predict the observed travel times (of the first arrivals in this case) with the generated model. A finite-difference Eikonal solver allows fast and accurate estimations of first-arrival travel times for transmitted, diffracted, or head waves, even for a very complex medium. This is quite different from the more typical ray-tracing approaches. An Eikonal solver can give a very prompt and stable prediction of first arrival times, irrespective as to whether the arrival is "most energetic", etcetera.

This is near-perfect for the foothills situation, and allows in the same timeframe many more iterations for convergence. The accuracy of this near surface velocity inversion is especially important for PSDM, where it becomes the starting point of its velocity field. Of course, for time processing, static corrections are done simply by applying the vertical time difference between the inverted surface model and a single constant velocity layer.

Now, let's look at some data examples from the foothills area where the above techniques are used to produce an accurate weathering model.

Field Data Examples

This tool has been tested on various data sets. We will present two examples: one from a 2D and the other one from a 3D survey. For both cases, various solutions as discussed above are tested and compared to the one using with tomographic inversion. These were reprocessing projects where the results could be compared to the previous sequences also.

A comparison at model level for 2D data is shown in Figure 2. Close inspection of the data shows large elevation variations on the surface which is one of the causes of near surface anomalies.

The results before (left hand side) and after tomographic inversion (right hand side) are shown in Figure 3 and 4. The model generated shows the lateral velocity variations, with some very interesting sub-surface features. In this case, the tomographic inversion statics solution provided superior data quality compared to the previous statics solution.

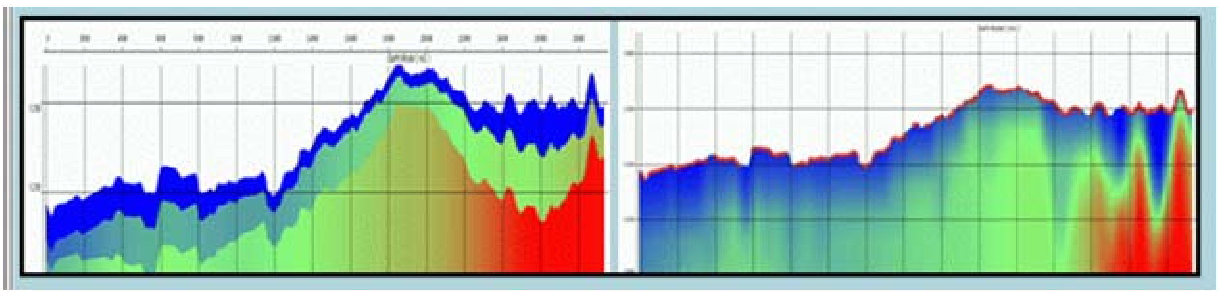
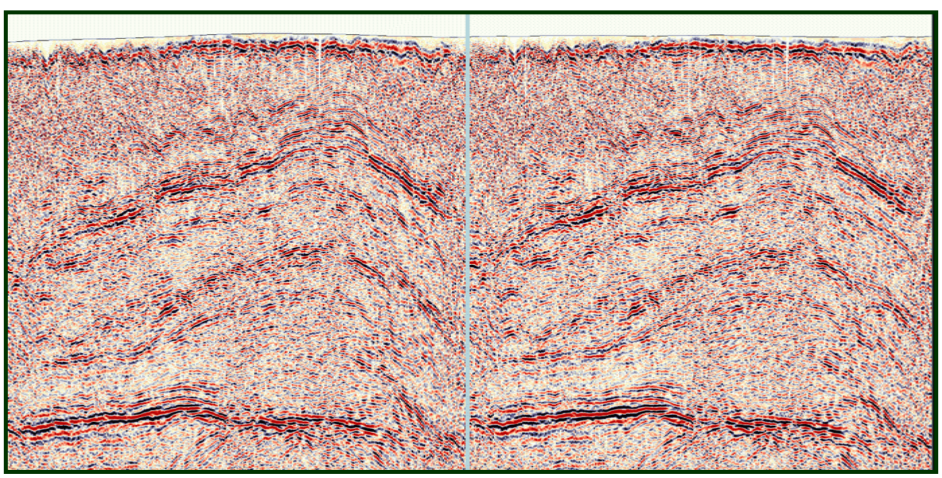


Figure 2. Layered vs. Tomo models



Elevation vs Tomographic Inversion

Figure 3. Stacks with statics

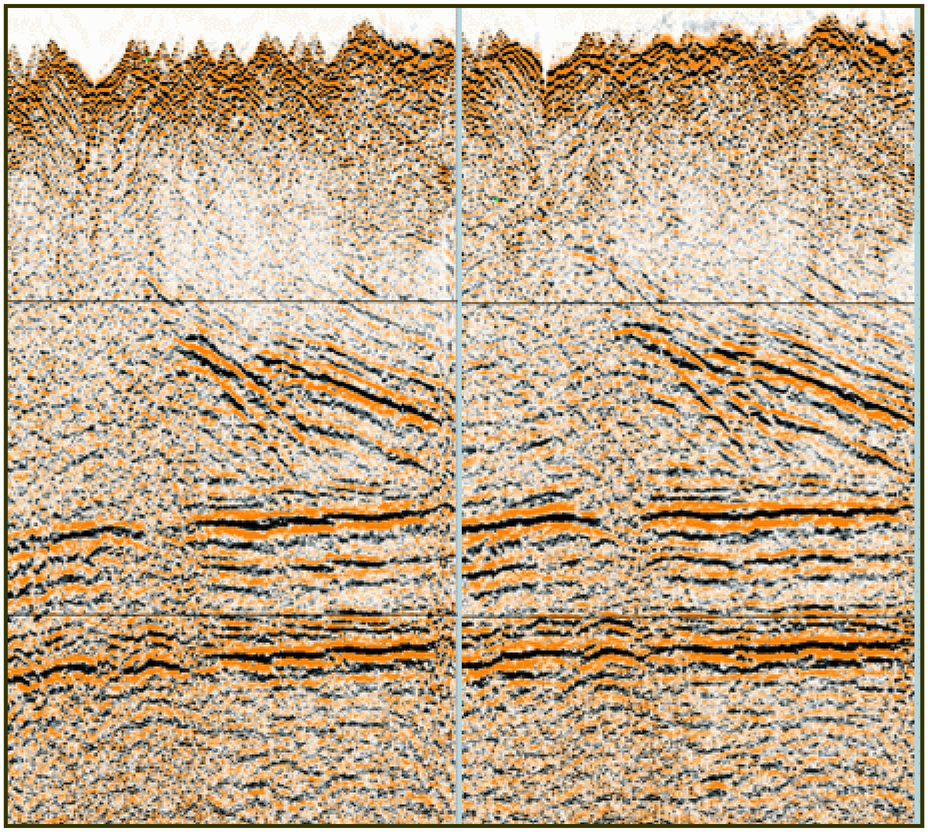


Figure 4. Stack with Statics (SW->NE); Elevation vs Tomographic Inversion.

Discussions and Conclusions

The results achived at the refraction statics level via tomographic inversion were well received by interpreters. This allowed them to see the zone of interest with a better results. In all the comparisons results were compared to a GLI solution for evaluation. As well, the near surface velocity models obtained from these solutions are typically used in PreSDM velocity model building.

Acknowledgements

We thank Talisman Energy and Pulse Energy Inc. for providing 3D and 2D data sets, Sylvestre Charles, Jianli Yang and Gray Billings for their contributions. We also thank to our colleagues who helped us in processing these data in Calgary processing center.

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