Velocity model update via inversion of non-parametric RMO picks over canyon areas offshore Sri Lanka

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Abstract

Conventional 2nd and 4th order RMO picking of moveout on CRP gathers for a complex sea-floor canyon area, offshore Sri Lanka, failed to capture the short wavelength velocity variation associated with the buried canyons, thus limiting the ability of subsequent ray-based tomographic inversion to resolve the required level of complexity.

In this study, we show results from autopicking performed using a new non-parametric scheme which in-part captured the complex residual moveout behaviour in CRP gathers, thus enabling the tomographic inversion to resolve more detail in the velocity model, and thereby facilitate improved imaging.

Introduction

The sea floor offshore Sri Lanka is incised with deep canyons, and the sedimentary sequence below these shows clear evidence of the presence of buried paleo-canyons with significant lateral velocity variation in comparison to the surrounding sediments.

Conventional 2nd and 4th order RMO picking of moveout on CRP gathers failed to capture the short wavelength velocity variation associated with the buried canyons, thus limiting the ability of subsequent ray-based tomographic inversion to resolve the required level of complexity.

In this study, we show results from autopicking performed using a new non-parametric scheme which in-part captured the complex residual moveout behaviour in CRP gathers, thus enabling the tomographic inversion to resolve more detail in the velocity model.

Conventional hybrid gridded tomographic results

For the vast majority of the study area (perhaps 90%) parametric picking and ray-based hybrid gridded tomographic inversion worked well (Jones, 2010, 2012). Hi-resolution tomographic inversion resolved velocity variation in the simpler overburden on a scale length of perhaps 2km, which was sufficient to remove the majority of the deeper image distortion, so as to facilitate yet deeper imaging. In addition, having captured much of the overburden velocity structure, this approach was able to resolve layering within the basalt and identify trapped sediment units (of about 200m thickness) within the basal flows. Details from these results are shown in Figure 1.
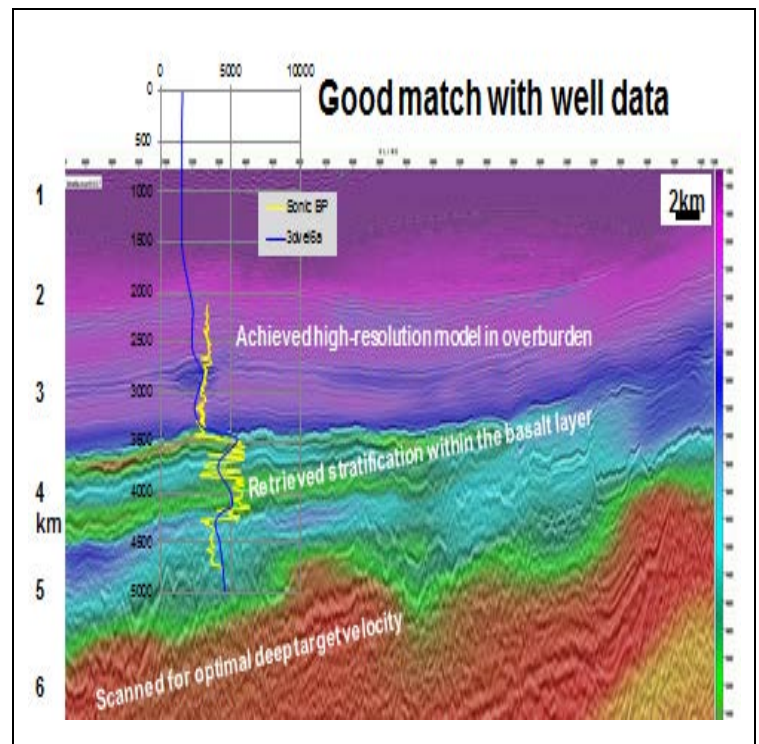

Figure 1 For the vast majority of the study area (perhaps 90%) parametric picking and inversion worked well. High-resolution tomographic inversion was able to resolve layering within the underlying basalt and identify trapped sediment units in the basalt flows

Failure of conventional parametric picking

Although the parametric approach worked well for the vast majority of the study area, in the paleo-canyon region, even after several iterations of 2nd and 4th order parametric picking, the tomography was still unable to resolve rapid lateral velocity variation caused by the buried paleo-canyons (Fruehn et al. 2014).

The paleo-canyon area is typified by a rugose sea bed with very rapid lateral change in both near-surface structure and associated velocities, as shown in Figure 2, and also in the zoomed section in Figure 3.

The imprint of the near surface short lateral scale length velocity variation causes unresolvable perturbations in the residual moveout behaviour in gathers below this region when using a conventional parametric auto-picker
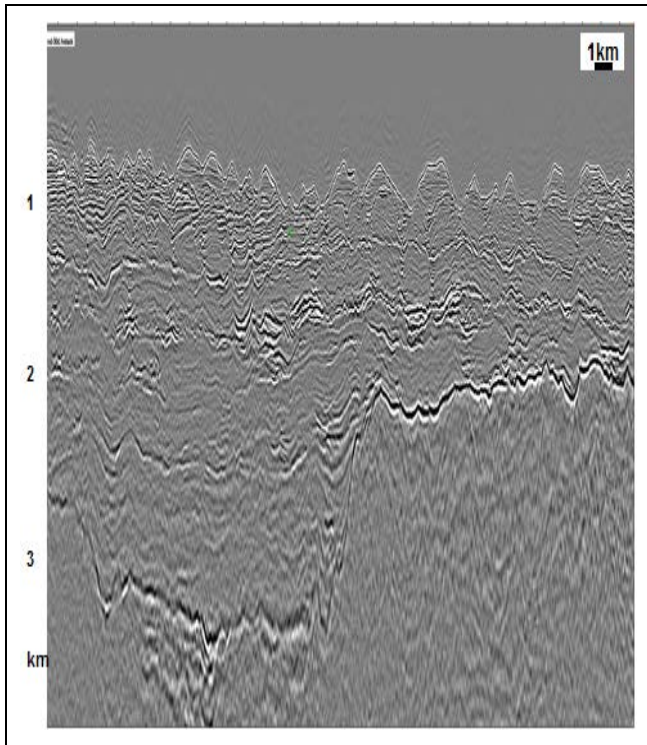
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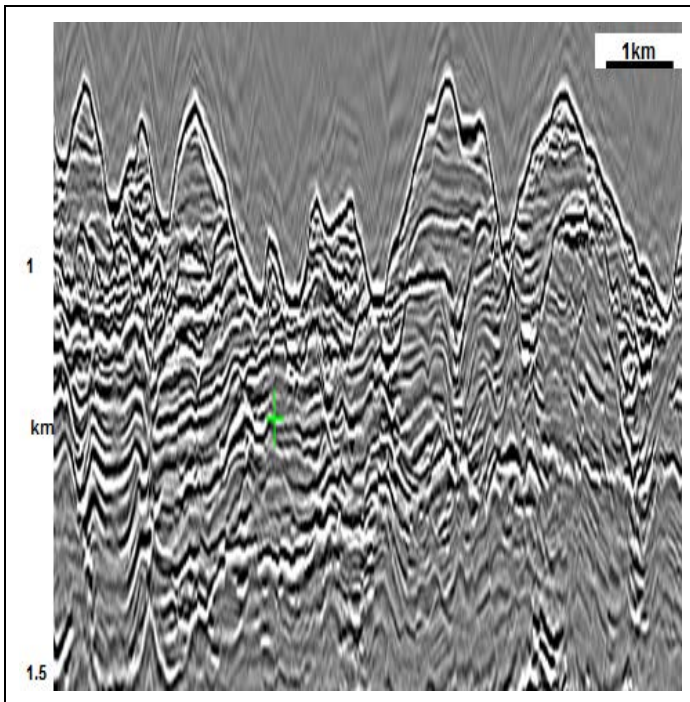*Figure 2 overview of the canyon area indicating the general level of seabed rugosity..*

Figure 4 compares the results of tomographic inversion using several iterations of conventional 2nd order parametric residual moveout picking with the results of tomography after two iterations of non-parametric (generalised) moveout picking, by comparing the remaining residual moveout error (characterised by a 2nd order analysis for both cases, so as to facilitate direct comparison).

The cyclic vertical stripes in the residual moveout error correspond directly to the paleo-canyons which have diverse sediment velocity fill (as expected). It is well known and well understood that such behaviour cannot be resolved with conventional tools.
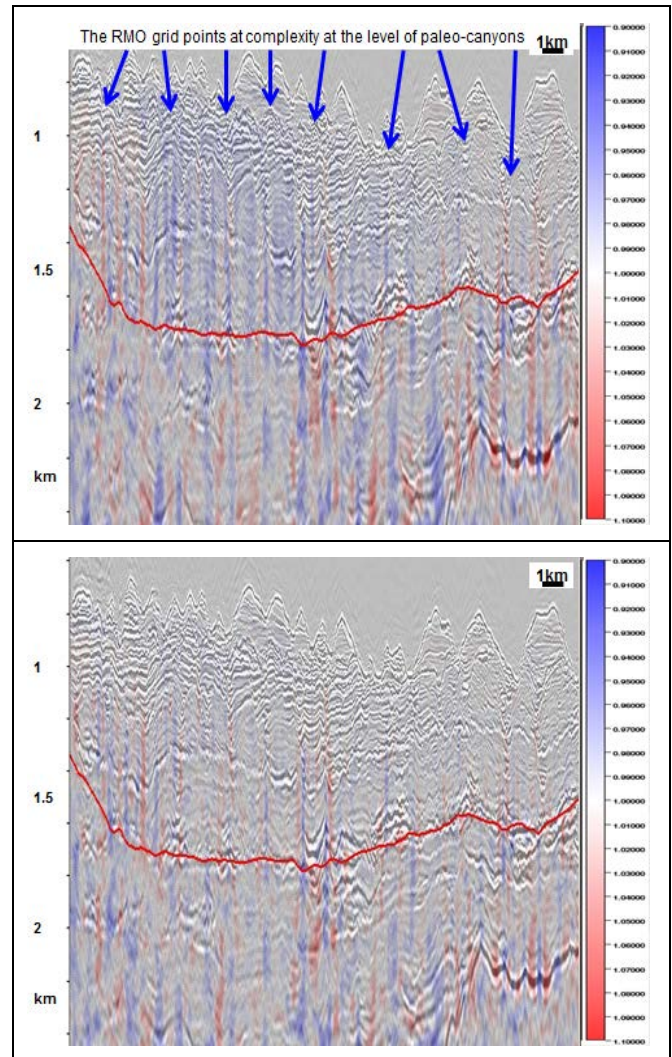

Figure 4 Top: After several iterations of 2nd order parametric picking, the tomography was still unable to resolve rapid lateral velocity variation caused by the buried paleo-canyons. The colour overlay indicates the RMO error (expressed as a percentage ratio to the input and updated velocities), here ranging from +- 10%. Bottom: after two iterations of non-parametric (generalised) moveout picking, the result is improved. For direct comparison, the colour overlay is again the result from a 2nd order parametric fit to the observed RMO behaviour in the CRP gathers.

Figure 3 detail of the near-seabed structure: the paleo-canyons have very diverse sediment fill with widely varying velocities which in-turn cause image distortion of the deeper structure.

The CRP gathers from 3D anisotropic Kirchhoff preSDM from the two approaches are shown in Figure 5. Overall, the CRP gather flatness is significantly improved for the deeper major reflectors by employing non-parametric picking. Gathers after conventional parametric update show sinuous RMO behaviour typical of unresolved overburden short-wavelength lateral velocity anomalies.

Following non-parametric update, to a large extent the sinuosity is removed, resulting in simpler RMO behaviour. Figure 6 shows the final Kirchhoff 3D preSDM image in the zone below the paleo-canyon complexity after several iterations of parametric picking as compared to the: corresponding image after two iterations of non-parametric (generalised) moveout picking. Overall the image is significantly improved for all deeper major reflectors.

Conclusions

Anisotropic velocity model building based on parametric 2nd and 4th order RMO picking of CRP gathers failed to resolve velocity complexity in the most complex areas offshore Sri Lanka area, although away from the buried canyon regions, these conventional techniques worked very well.

Recent advances in non-parametric picking algorithms have enabled us to successfully resolve some additional complexity in the velocity structure using ray-based tomographic inversion of the non-parametric picks.

Acknowledgements

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References

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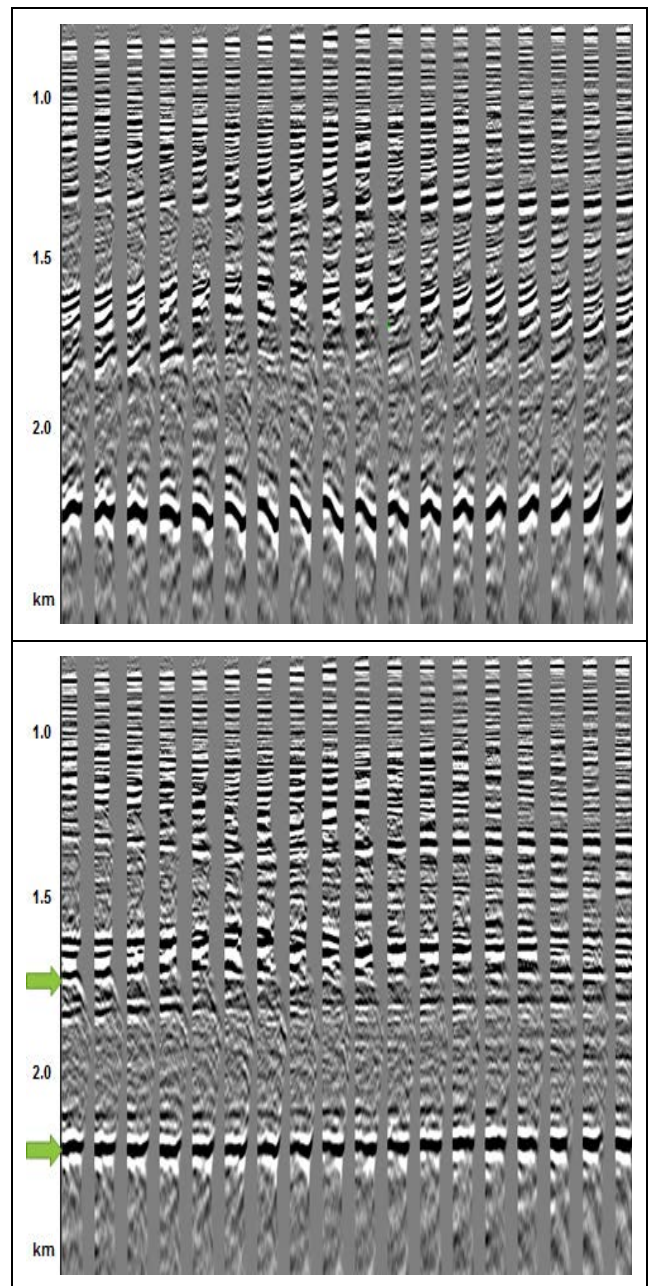
Figure 5 *Top: CRP gathers in the zone below the paleo-canyon complexity after several iterations of parametric picking (5km maximum offset). Bottom: after four iterations of non-parametric (generalised) moveout picking, the result is improved. Overall CRP gather flatness is significantly improved for these deeper major reflectors.*
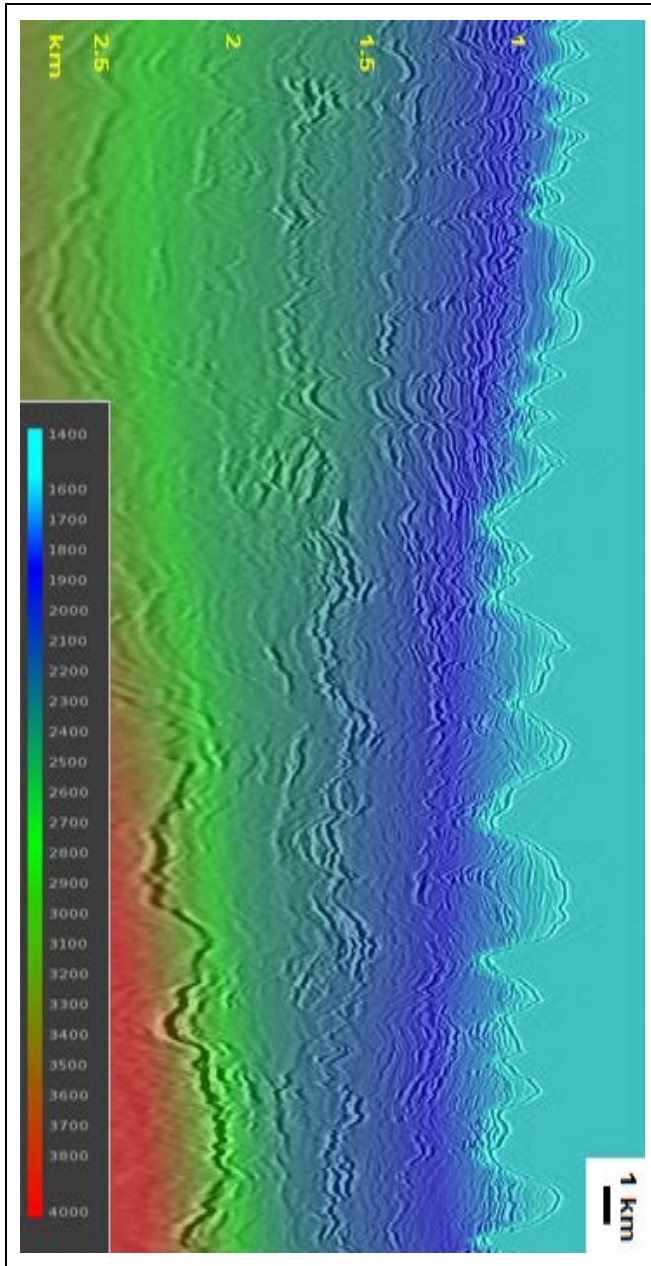
***Figure 6** a: Final Kirchhoff 3D PreSDM image in the zone below the paleo-canyon complexity after several iterations of parametric picking, with interval velocity overlay.*
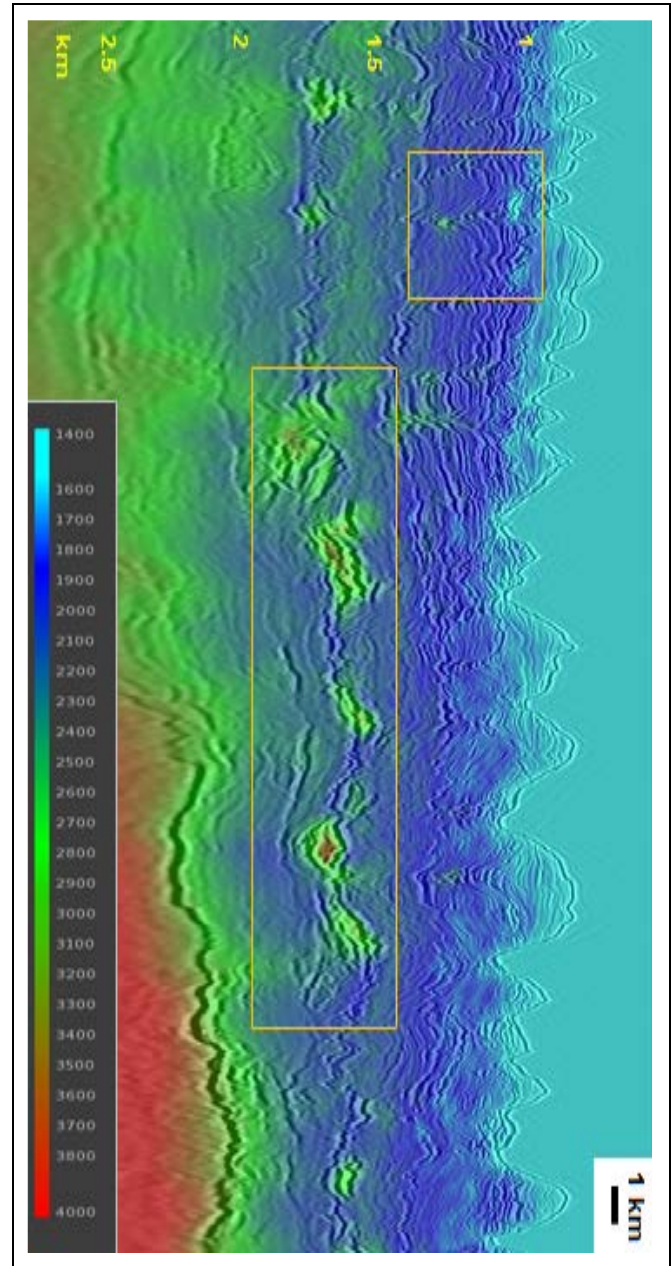
***Figure 6** b: Corresponding Kirchhoff 3D PreSDM image after four iterations of non-parametric (generalised) moveout picking. The boxes indicate areas where higher resolution velocity information has been recovered. Overall the image is improved for all deeper major reflectors.*