Partial stack seismic data used for AVO analysis and deep learning

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Summary

Partial stack seismic data has its advantages to both the full stack data and prestack data. Comparing to prestack data, partial stack data is much smaller in size which make it easily accessible on interpreter's desktop. Comparing to full stack data, it still contains some if not all the critical information such as AVO. This study focuses on tuning some of the poststack interpretation workflows to incorporate and utilize partial stack data. Specifically, partial stack data is used to compute common AVO attributes, and the analysis can be done subsequently. However, to fully utilize the partial stack, both the partial stack data and the computed AVO attributes are used in a deep learning workflow which is to predict well log properties from seismic attributes using neural networks. The conclusion is that the best results are from the workflow using both partial stack data and the computed AVO attributes.

Method

First, AVO attributes are calculated using the partial stack data. Details about this are not covered here because it is an established method. In this study, I have computed gradient, intercept, and gradient-times-intercept attributes from three partial stack data (near, middle and far angle stack).

Then, AVO analysis can be done.

Next step, I will define an interesting zone, and upscale well log, Gamma ray (GR), of the wells within the zone to seismic resolution. Many different seismic attributes such as spectral decomposition are calculated too. Final step is to create a multi-layer neural network (NN) and to train it using the upscaled well log (in this study GR), and the calculated seismic attributes, as well as partial stack data and its derived AVO attributes (Gradient and Intercept).

Once the NN is properly trained, the prediction is made to create a well log volume.

Examples and Conclusions

Volve Field, located in the southern Norwegian North Sea, is the study area. One full stack seismic data and three angle stack data, as well as more than a dozen wells are used.

Figure 1 shows a map of top of the reservoir. The pink line, linking wells, shows the location of the seismic cross section shown in other figures.

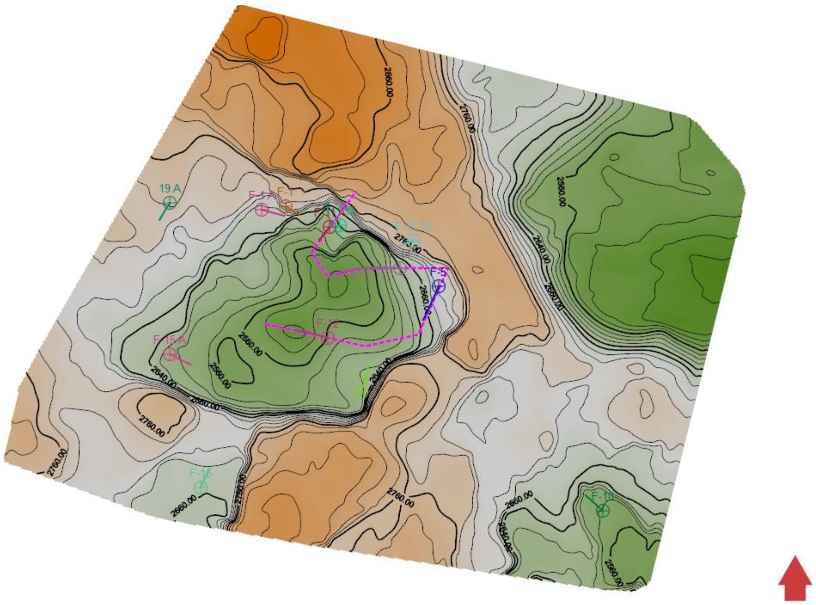


Figure 1 Map of top of the reservoir. The pink line is an arbitrary line used in other figures.

Figure 2 shows a seismic cross section with the interesting zone overlaid which represents one AVO attribute: *gradient-times-intercept (GTI)*. The well logs shown here are GR (cooler color, higher value). The correspondences between GTI and GR at well location can be seen in this figure. This also holds true away from wells as can be seen in Figure 3.

Figure 3 shows the predicted GR from NN using both seismic attributes and partial stack data, as well as its derived AVO attributes. A good match between the predicted GR and GR log at well location can be observed.

In Figure 4, the results are calculated without using partial stack data. From Figure 3 and Figure 4, it can be seen that the results using partial stack data is clearly better than those without. Figure 5 shows a comparison of NN performance between these two scenarios. From the distribution of points in the crossplot and the correlation coefficients (R value in the figures), it can be concluded that partial stack data does improve NN training. I have also done the similar process using three partial stack data but not using AVO attributes. The NN performance is between the two scenarios explained above. This probably means that the current NN cannot extract the full information from partial stack data such as AVO. On the other hand, using AVO attributes alone is not the optimal approach because some of the information in the partial stack data will not exist in AVO attributes because AVO attributes derived from partial stack is a two-term approximation.

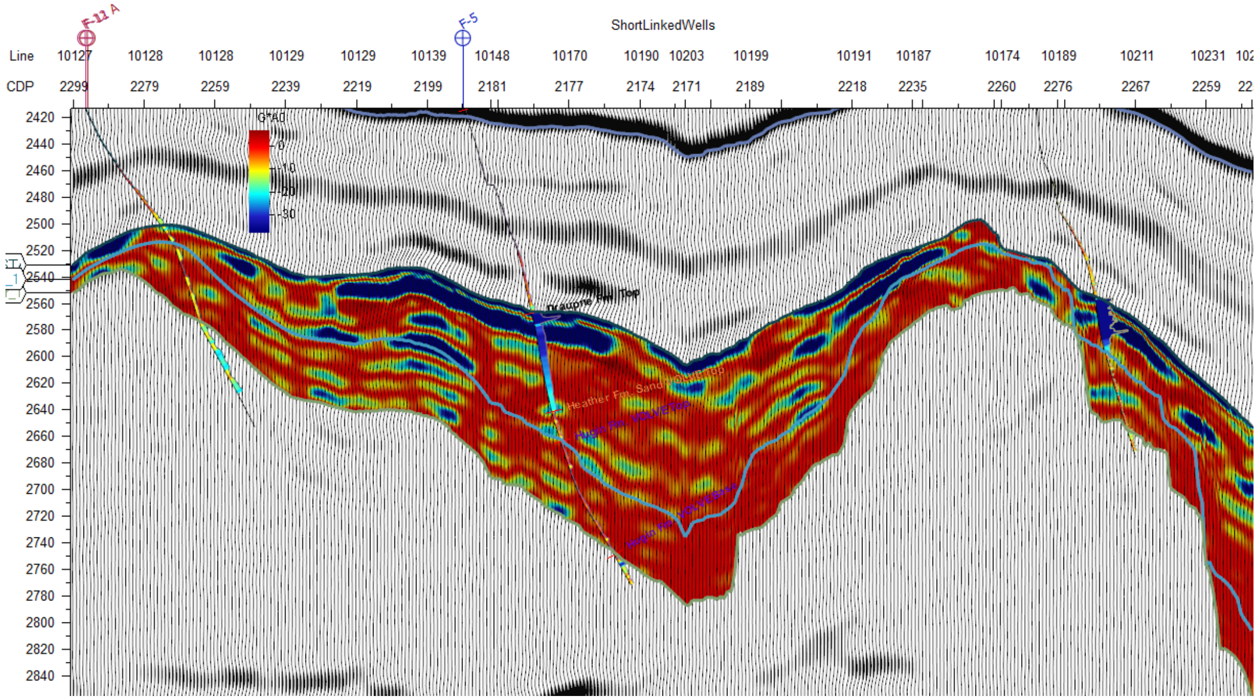


Figure 2 Seismic cross section shows the computed gradient-times-intercept, as well as GR logs.

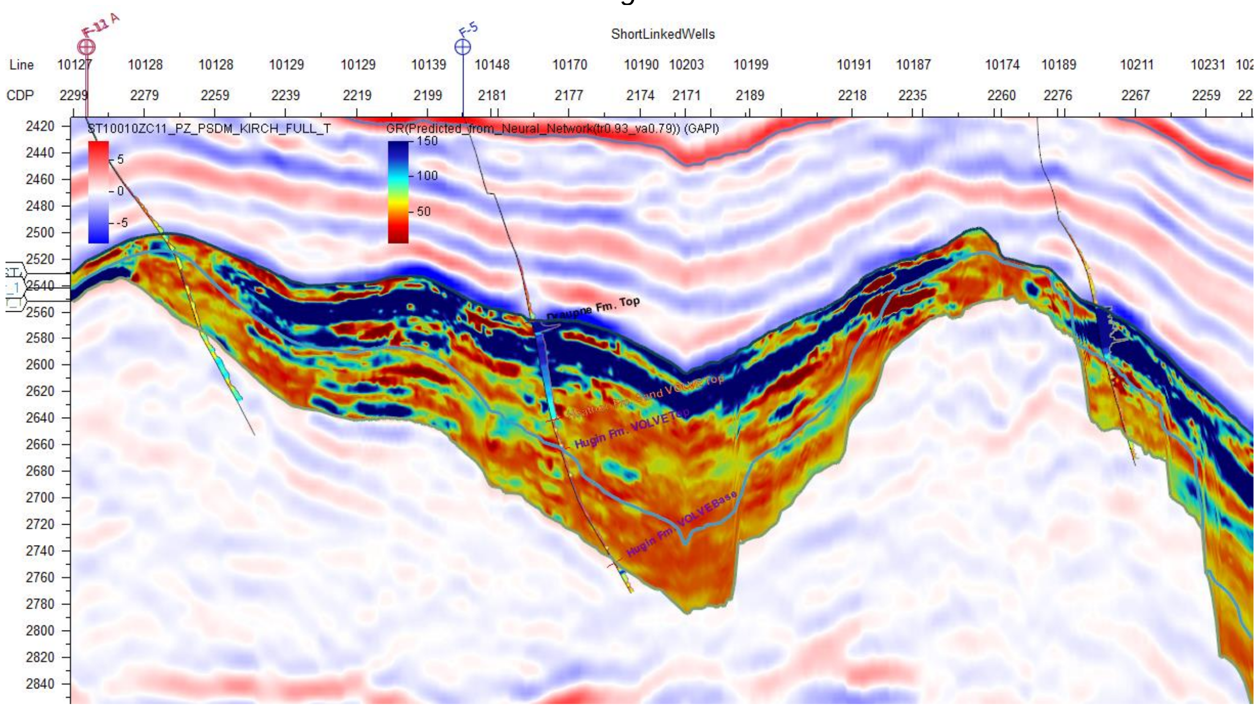


Figure 3 Seismic section overlaid with NN predicted GR. All three partial stack and the computed gradient, as well as intercept attributes are used.

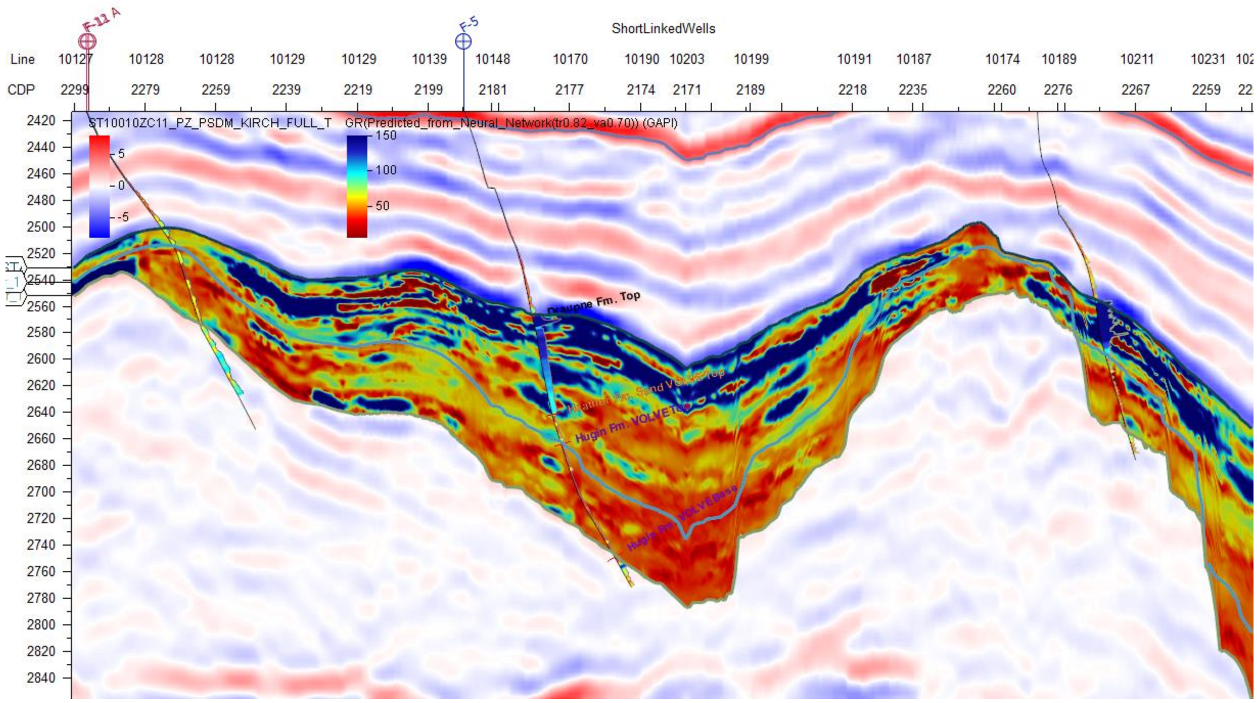
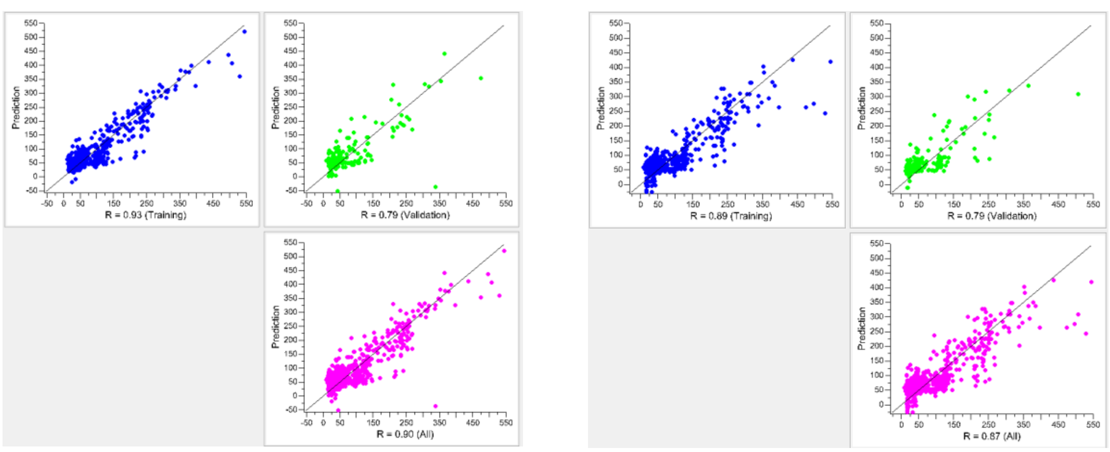


Figure 4 Seismic section overlaid with NN predicted GR. Partial stack and the computed gradient, as well as intercept attributes are not used.



(a) Partial stack data are used. (b) Partial stack data are not used.

Figure 5 Crossplot between predicted GR and the true GR at wells.

Acknowledgements

I thank Geomodeling Technology Corp. for support of this work and permission to present.

References

Improving porosity and gamma-ray prediction for the Middle Jurassic Hugin sandstones in the southern Norwegian North Sea with the application of deep neural networks: Satinder Chopra, et al. **Interpretation** Vol 10, Issue 1, 2022.