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Simultaneous inversion for λρ and μρ via machine learning from multi-component poststack seismic data

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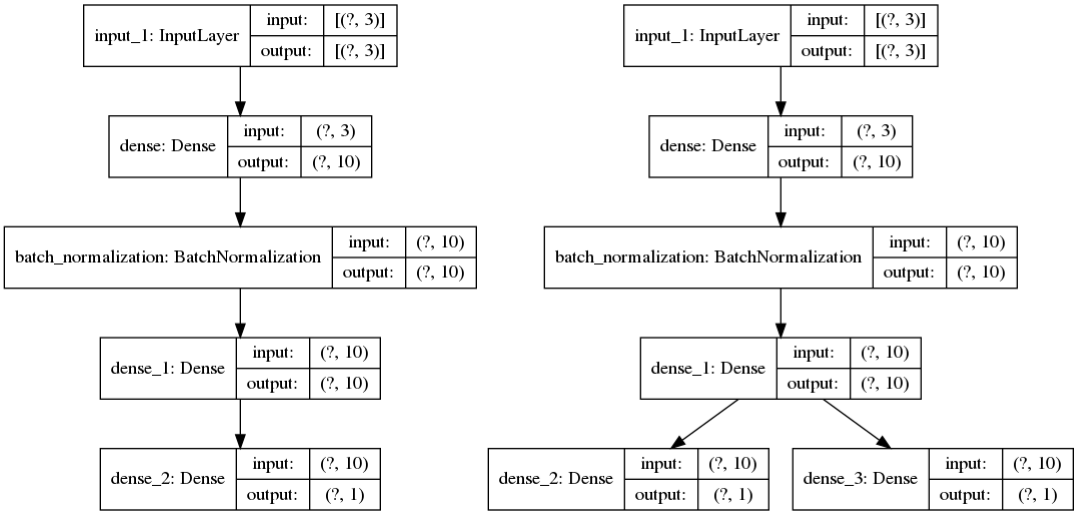
Summary

λρ and μρ are the results of pre-stack inversion and very useful for seismic interpretation. The author presented the work last year to invert λρ and μρ separately from poststack P-wave seismic data and its attributes via machine learning. This time, the author explores the idea to invert λρ and μρ simultaneously and uses multi-component poststack seismic data. The results have improved because these two variables are related, and horizontal seismic component contains precious extra information.

Method

To train a neural network and predict λρ or μρ using deep learning approach, the most popular sequential model can be used. However, we know λρ and μρ are somewhat related, better results can be achieved if they can be predicted simultaneously. In this case, sequential model cannot be used, instead, functional model is to be used. The diagram below shows the difference. The sequential model has one output layer which is λρ or μρ. The functional model has two output layers which are λρ and μρ respectively.



The sequential model (left) used to invert λρ and the functional model (right) used to invert λρ and μρ

On the other hand, I imported horizontal component of seismic used together with vertical component (P-wave seismic) to invert λρ, believing extra information brough by the horizontal component will truly give reliable results than only using P-wave seismic data. When train the

neural network at well location using attributes from both P-wave seismic and horizontal component, there is an interesting observation that the most correlated input with the well log is the horizontal component seismic.

Results and Conclusions

Taking one well as an example, the raw logs used to train the model are displayed in Figure 1.

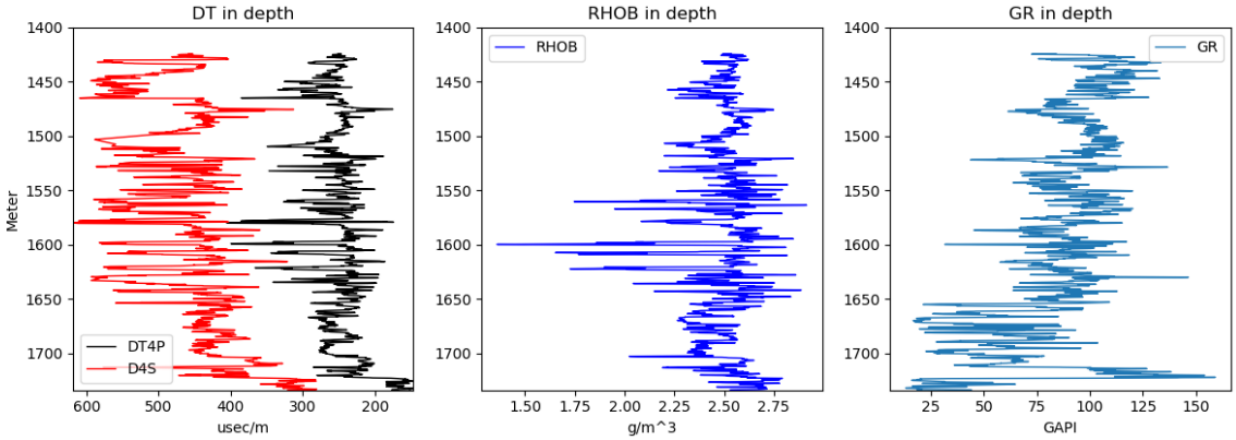


Figure 1 Sonic (DT), density (RHOB), and gamma ray (GR) logs of a well

Based on the raw logs, λρ and μρ logs can be calculated, predicted separately, and predicted simultaneously. Figure 2 shows a comparison of λρ log resulted from these three approaches. However, it is difficult to see the differences from this log curve plot. So, I cross-plot λρ and μρ logs and show in Figure 3.

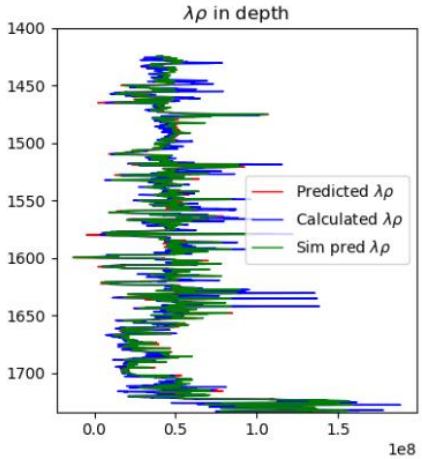


Figure 2 Comparison of λρ using simple calculation (red), prediction separately (blue) and prediction simultaneously (green).

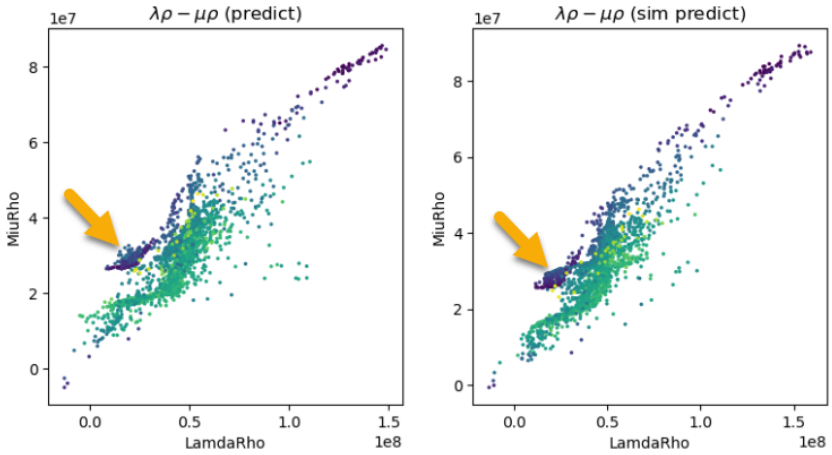


Figure 3 λρ and μρ cross-plots colored by GR. The left figure shows the results predicted separately and the right plot shows the results predicted simultaneously. Yellow arrow points to the low GR cluster.

From Figure 3, it can be seen that the low GR cluster indicated by the yellow arrow, which represents the producing sand, is tighter in the plot (right) by simultaneous inversion than in the plot (left) inverted separately.

The workflow to predict a well log (λρ) volume from well logs and seismic attributes was introduced during Geoconvention 2020[3]. This time, the workflow is not changed, but horizontal seismic component are used along with P-wave seismic. Figure 4 shows a comparison of results, a roughly 12ms interval around the reservoir zone . Left figure shows the results without using horizontal seismic component, presented last year. Right figure shows the results using horizontal seismic component along with P-wave seismic. It is clear that using horizontal seismic component makes the results more accurate and much less artifacts and false detection, especially in the northern part.

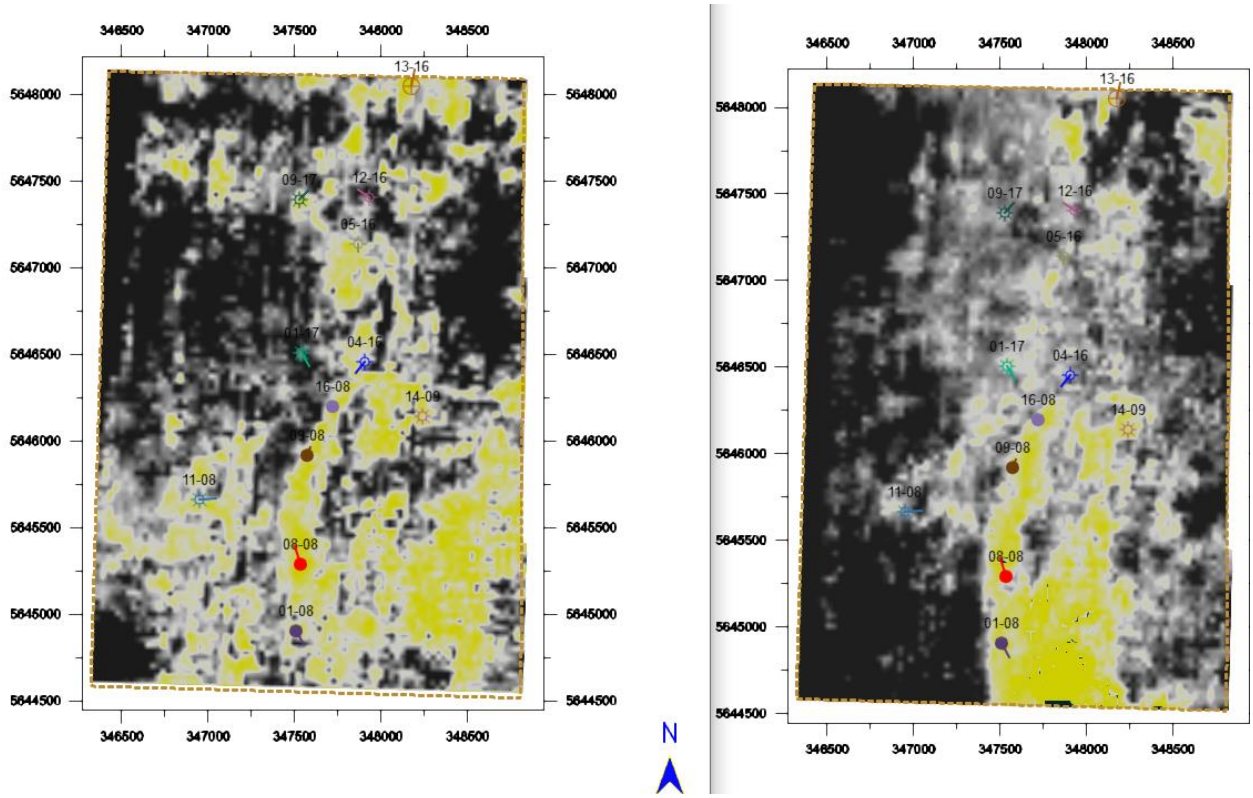


Figure 4 Predicted λρ without (left) and with (right) horizontal component seismic (solid well symbol represents producing well)

Acknowledgements

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References

1. AVO and Lame' constants for rock parameterization and fluid detection, Goodway W. Recorder 2001, 26, 39-60.

2. Integrated geological and geophysical interpretation case study, and Lamé rock parameter extractions using AVO analysis on the Blackfoot 3C-3D seismic data, southern Alberta, Canada, Jocelyn Dufour, et al.
GEOPHYSICS 2002 67:1, 27-37

3. Neural network inversion of λρ and μρ from post-stack seismic attributes, Rongfeng Zhang, et al. Geoconvention 2020