Using corrected phase to localize geological features in seismic data

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Abstract

We consider the time-frequency analysis method, basis pursuit, as a method to extract spectral information from seismic data. We look specifically at the phase attribute produced from the results of running basis pursuit on various data sets. We explore the numerical results of the derivative of the corrected phase attribute proposed in (Han et al., 2015) on other geological data sets. We consider the phase attribute provided by other spectral decomposition methods, continuous wavelet transform and synchro-squeezing transform, and apply the derivative of the corrected phase process to these attributes. We end with a comparison of the results for basis pursuit to those of continuous wavelet transform and synchro-squeezing transform.

Data Sets

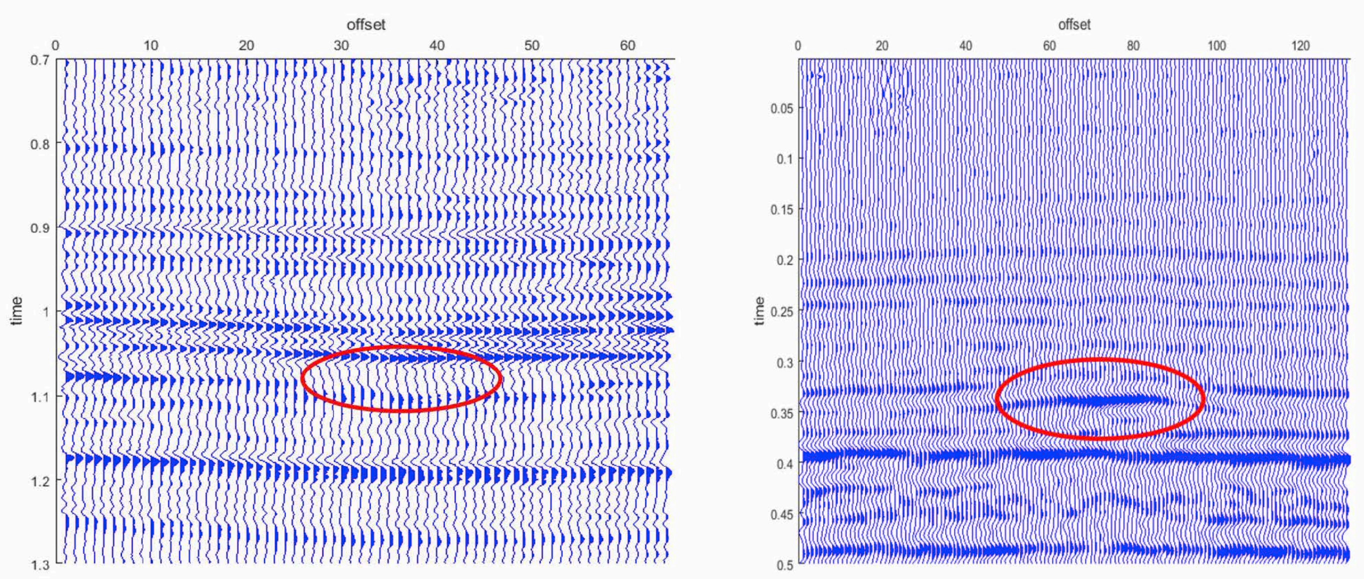

Figure 1: The valley data set which is from the CREWES Blackfoot data; the valley lies between offsets 30-40 and time 1.05s (left). The reservoir data set is named for the geological structure we are interested in locating; the hydrocarbon reservoir lies at around offsets 60-85 and time 0.34s (right).

Phase attribute results from basis pursuit

Valley data set

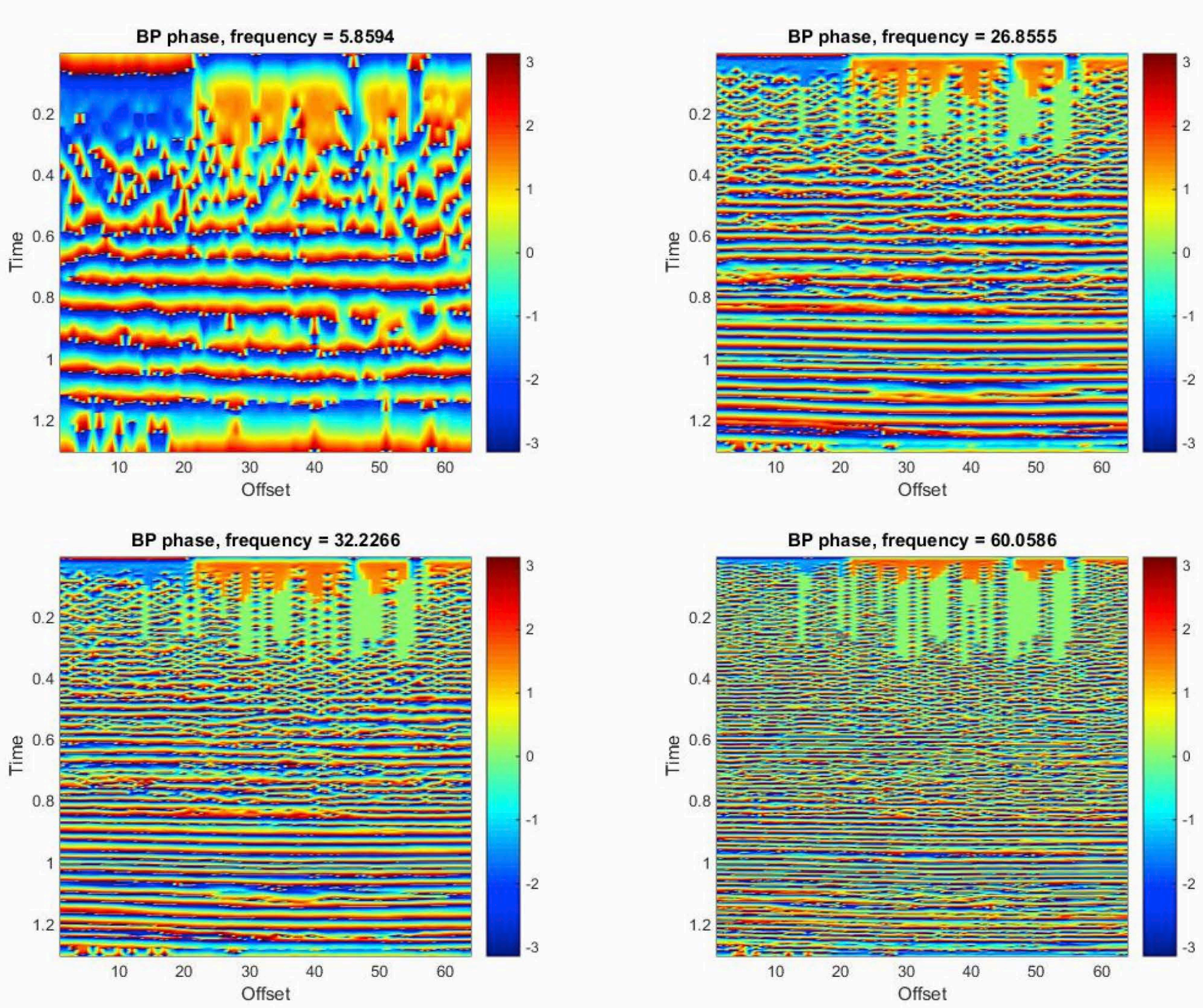

Figure 2: Phase attribute for valley post-stack data: Constant frequency slices obtained by applying basis pursuit to the valley data set at frequencies approximately 5 Hz, 26 Hz, 32 Hz, and 60 Hz.

Reservoir data set

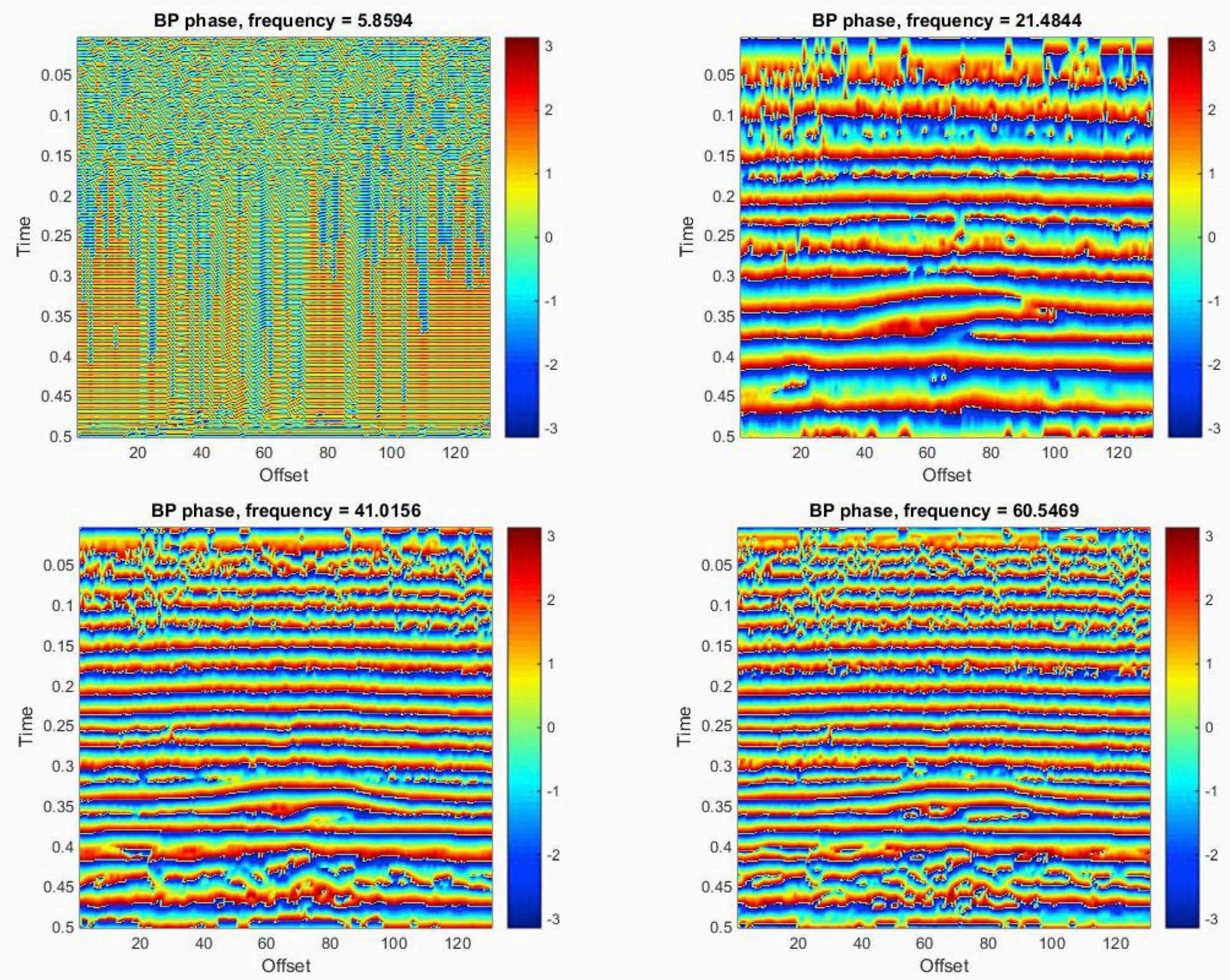

Figure 3: Phase attribute for reservoir post-stack data: Constant frequency slices obtained by applying BP to the reservoir data set at frequencies approximately 5 Hz, 20 Hz, 40 Hz, and 60 Hz.

Corrected phase method

In (Han et al., 2015), an attempt was made to remove the arbitrary coherent lines seen in the phase attribute. This process is called the corrected phase method. This method involves unwrapping the time-dependent curve in the phase attribute and fitting it to a quadratic equation. Then, the quadratic is subtracted from the original curve.

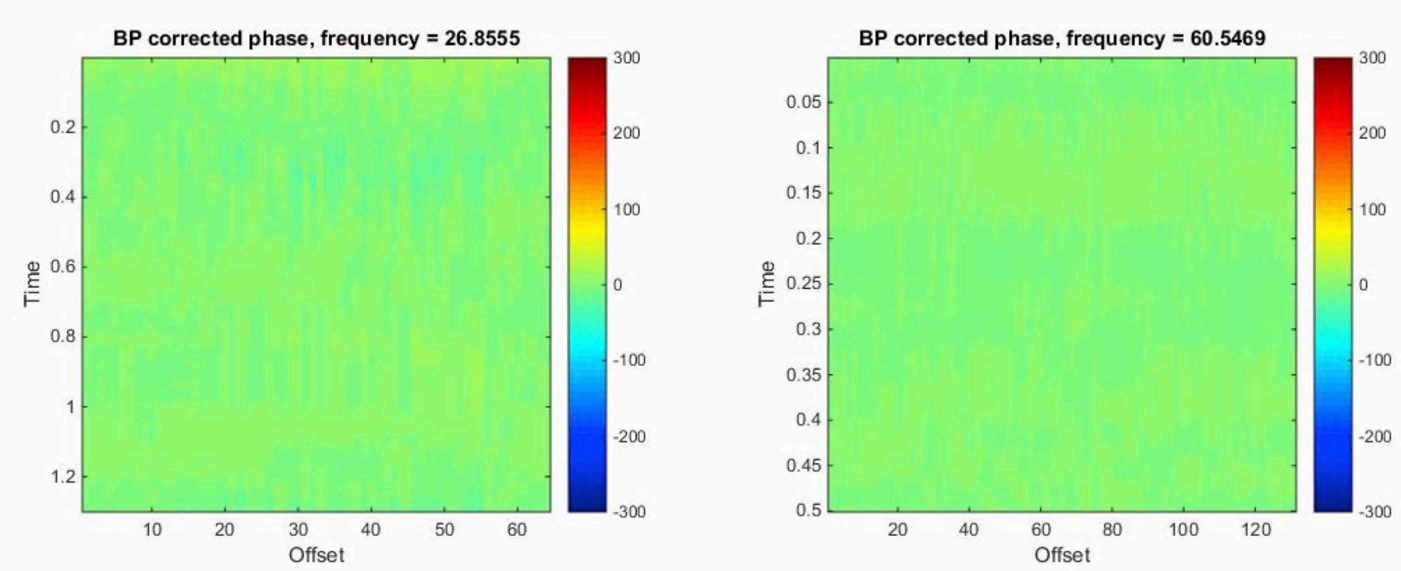

Figure 4: Corrected phase attribute for the valley at approximately 20 Hz (left). Corrected phase attribute for the reservoir at approximately 60 Hz (right).

Derivative of the corrected phase method

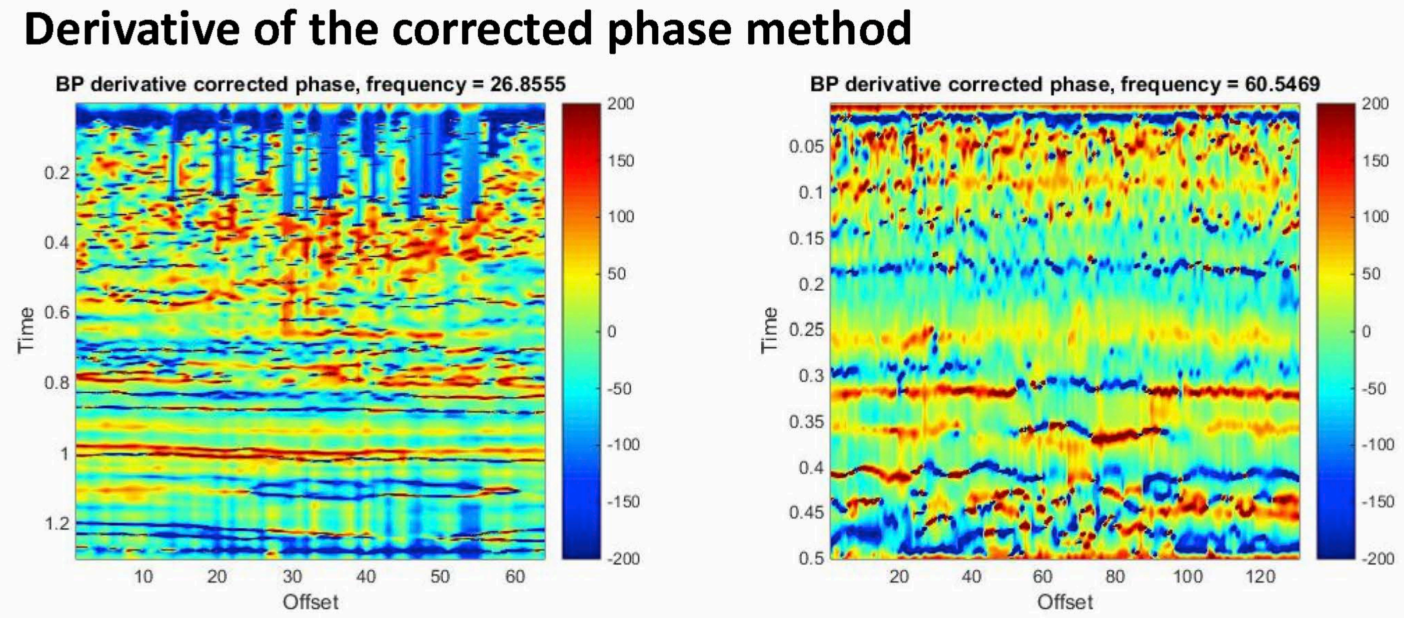

Figure 5: Derivative of the corrected phase attribute for the valley at approximately 26 Hz (left). Derivative of the corrected phase attribute for the reservoir at approximately 60 Hz (right).

Application of other time frequency analysis methods

Continuous wavelet transform

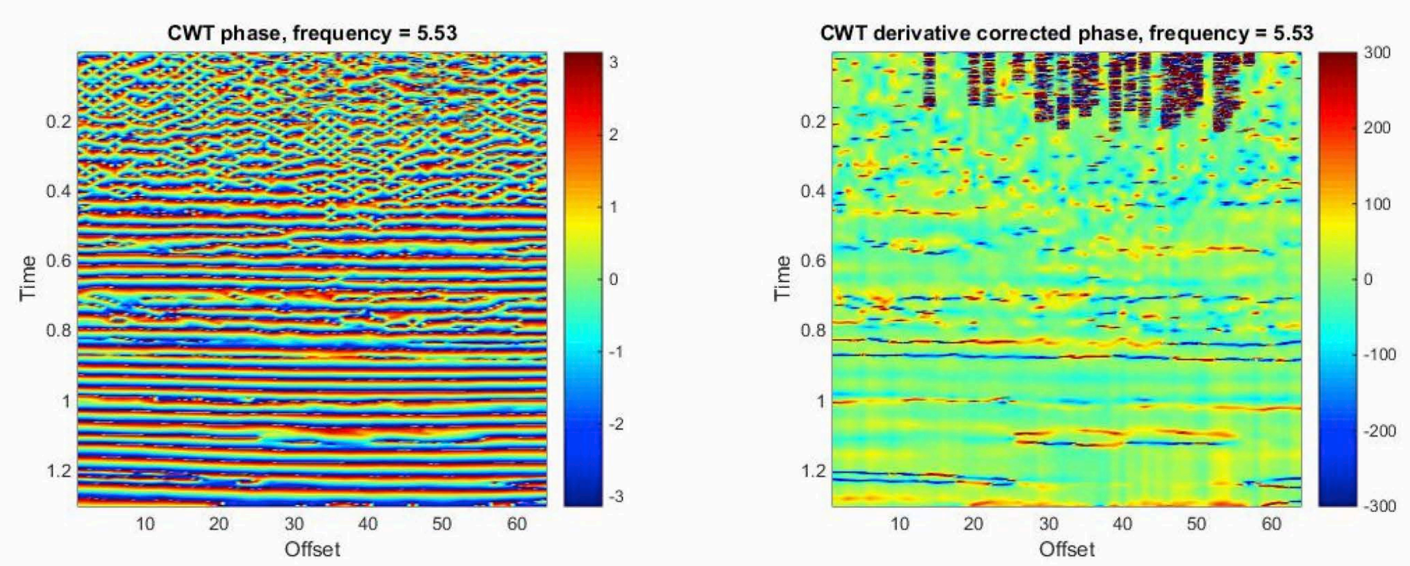

Figure 6: Phase attribute for valley post-stack data using CWT at frequency approximately 5 Hz (left). Derivative of the corrected phase for valley post-stack data using CWT at frequency approximately 5 Hz (right).

Synchro-squeezing Transform

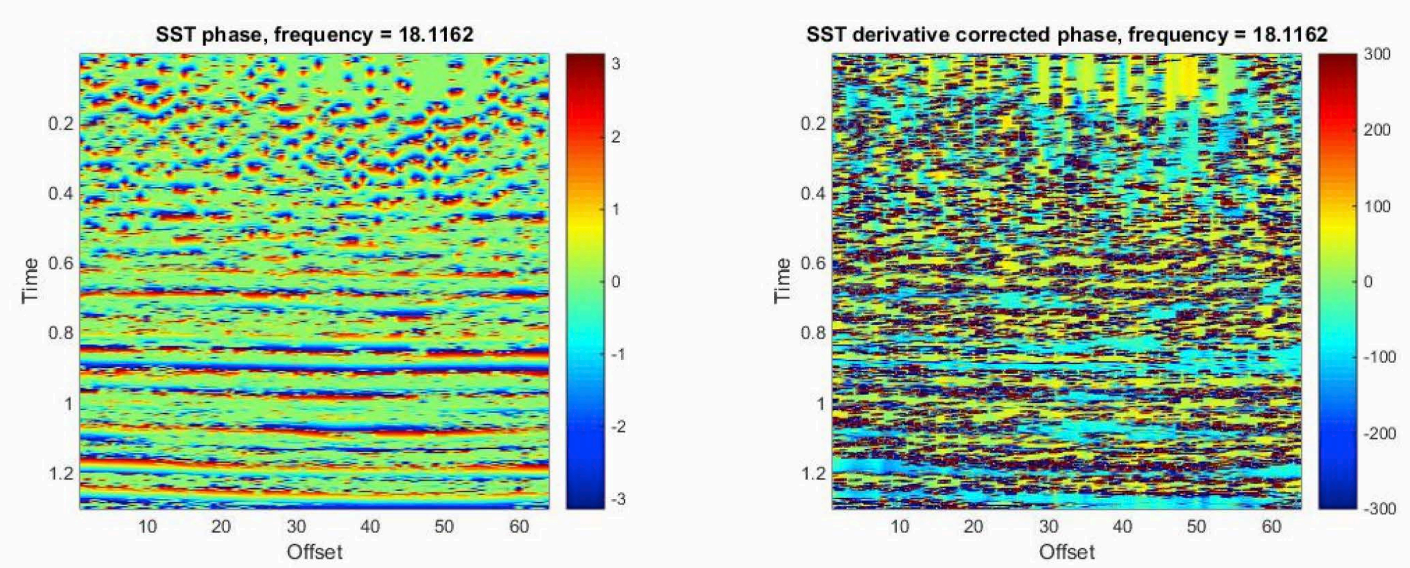

Figure 7: Phase attribute for valley post-stack data using SST at frequency approximately 18 Hz (left). Derivative of the corrected phase for valley post-stack data using SST at frequency approximately 18 Hz (right).

Future Work

Our next step is to apply the derivative of the corrected phase method to pre-stack data. We will also consider applying this new method to 3 component data. Another step in extending these results will be to consider how well the derivative of the corrected phase attribute performs on data sets which contain more noise.

Conclusions

We demonstrated the effectiveness of basis pursuit in localizing geological features when consulting the phase attribute. We also exhibited the extended capabilities of locating geological structures in seismic data once the phase is corrected and we considered the derivative of the corrected phase. We observed that to some degree the success of the derivative of the corrected phase method is dependent on how clearly the phase attribute localizes the geological feature. This result is evident with all time-frequency analysis methods we considered.

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References

Han, J., Ciocanel, M.-V., Hardeman, H., Nasserden, D., Son, B., and Ye, S., 2015, Deducing rock properties from spectral seismic data - final report: Institute for Mathematics and its Applications Math Modeling XIX: Math Modeling in Industry Proceedings, 1–21.