Using corrected phase to localize geological features in seismic data
Heather K. Hardeman* and Michael P. Lamoureux
heather.hardeman@ucalgary.ca, mikel@ucalgary.ca

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 BP 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.

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.

Acknowledgements
The authors gratefully acknowledge the financial support of the industrial sponsors of the CREWES project at the University of Calgary. This work was funded by CREWES industrial sponsors and NSERC (Natural Science and Engineering Research Council of Canada) through the grant CRDPJ 461179-13 and the second author’s Discovery grant. CGG and the CREWES consortium of Calgary, Alberta graciously provided both data and software tools for the project.

References