

2015 Qadeemah Fault Survey Supervirtual Interferometry Project

Abdullah Alhadab & Maximillian Kosmicki
Basic Seismology, King Abdullah University of Science and Technology

I. Introduction

In October 2016, an near surface seismic survey was performed by students of the Basic Seismology course at King Abdullah University of Science and Technology. The objective of the survey was to spatially locate the extent of the Qadeemah fault that is believed to run beneath University as well as give to students hands on experience with seismic data fieldwork and data processing. The fault has been located previously to the north of the university using both seismic and resistivity measurements [Hanafy, 2011]. As such, a seismic survey was designed and implemented over an period of a week and different student groups tested various data processing algorithms on the data for their final projects. This report covers the usage of the Supervirtual Interferometry (SVI) on the data in order to increase the ability to pick refraction first arrivals.

II. Survey Design



Figure 1: Location of 2015 Survey in Red

The survey was conducted over the weekends of the 9th and 16th of October. The survey was 1.2 kilometers long and had 240 receiver channels. The receiver spacing was 5 meters and there was a shot performed at every receiver (240 shots). The shots were stacked 20 times before being saved. Time sampling was 0.001 seconds.

Over the course of the survey a few sources of noise were noted in the field and were later seen to influence the data quality in the raw returns. The summary of the results were as follows:

- Survey located next to an active construction site
- Survey located next to an occasionally busy road
- High wind on most days of survey
- Poor geophone coupling, broken geophones, noisy geophones, etc
- weak source and insufficient stack relative to other noise sources

III. Data Processing

i. Noise Analysis

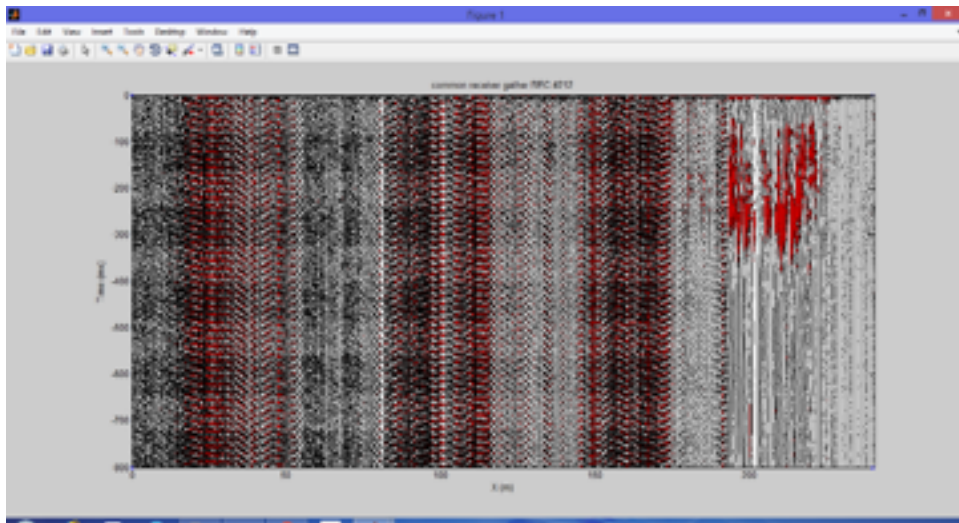


Figure 2: Common Receiver Gather of Receiver #212

An example of the data quality (or lack of it) can be seen in Figure 2. Many of the receivers are not recording any of the seismic waves generated by the source and the ones that do have a low SNR.

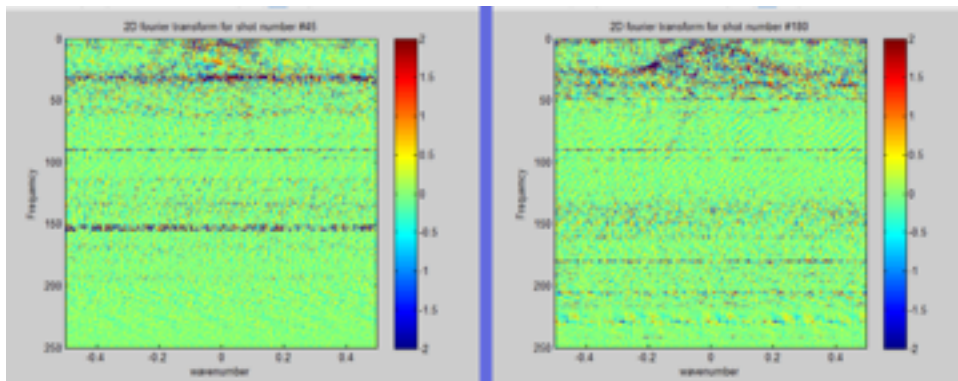


Figure 3: FK domain view of Shots #45 and #180

When analyzing the spectral content of the data (Figure 3), it can be seen in the lateral banding in the frequency domain that many receivers are not recording any data in the first place. In addition when looking at the amplitude spectrum of the shots, spikes can be seen which indicate noisy traces (Figure 4).

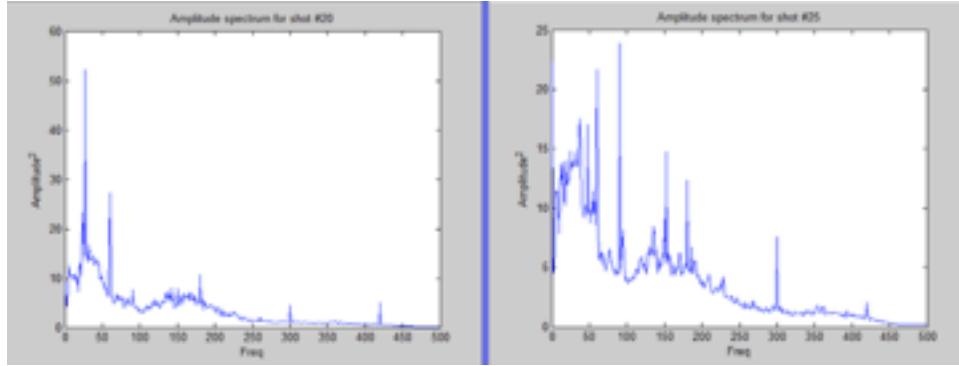


Figure 4: FK domain view of Shots #45 and #180

ii. FK Filtering and Bandpass Filtering

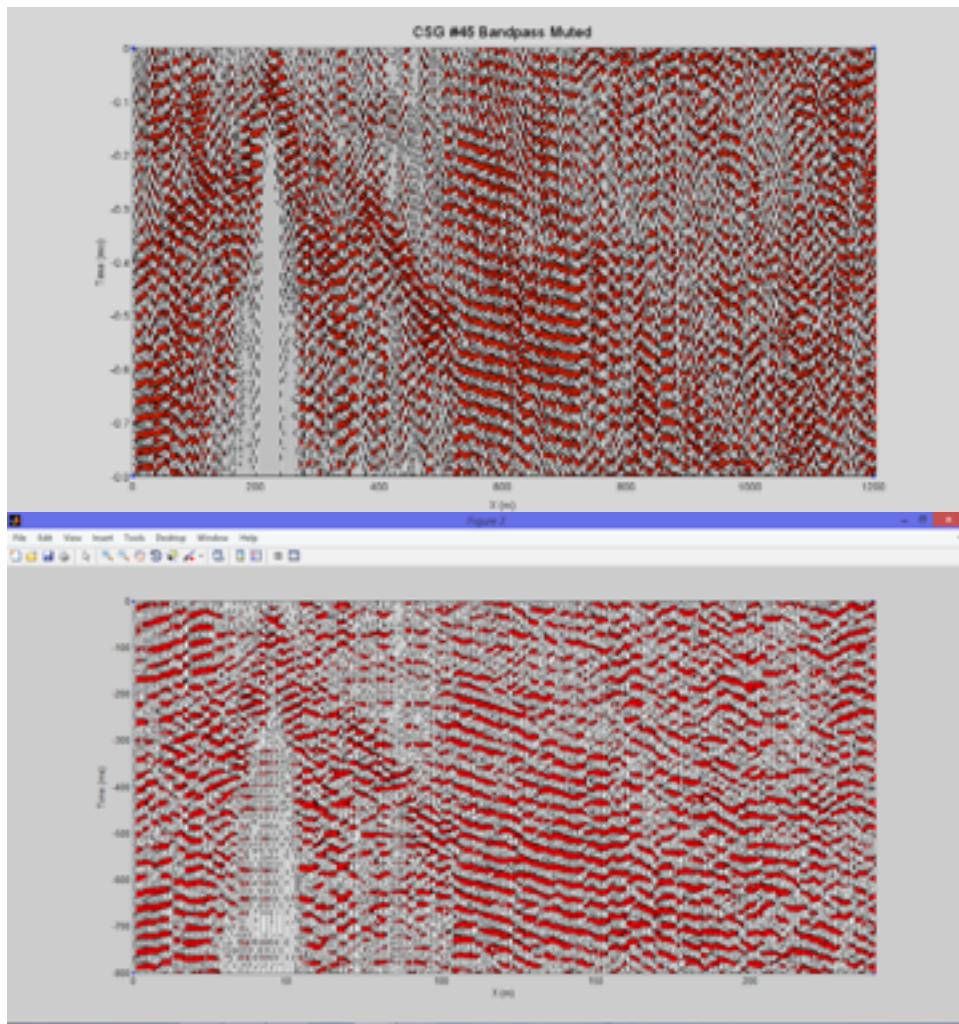


Figure 5: (a) bandpass filtered shot 45 and (b) FK filtered shot 45

In order to increase data quality FK domain and Bandpass filtering were performed on the data in order to amplify refraction arrivals. Parameters for the bandpass filter were frequencies 25,35,40, and 45. A sample filtered CSG for the two cases can be seen in Figure 5. Because of the large amounts of both random and coherent noise in the dataset, filtering by itself was not sufficient in improving data quality.

iii. Supervirtual Interferometry



Figure 6: Illustration of the SVI Method

The SVI method is the main focus of this report and the general method is as follows. With a typical seismic dataset, a cross correlation performed on the data will produce a result which is similar to as if the common raypath terms had been removed, this is going from the first panel of Figure 6 to the second. For all sources to the left of the above geometry the result will always resemble the 2nd panel, with a virtual source at the location of the refractor starting at a negative time. One can stack over all the sources to increase the SNR for the refraction arrival.

Similarly one can then do the reverse and convolve the arrival along the ray path of the source to the first receiver with the virtual arrival. The negative ray path term from the virtual arrival will cancel with the portion of the arrival between the refractor and the first geophone. This will result in a ray path from the source to the second receiver. This produces an additional increase in SNR.

IV. Results

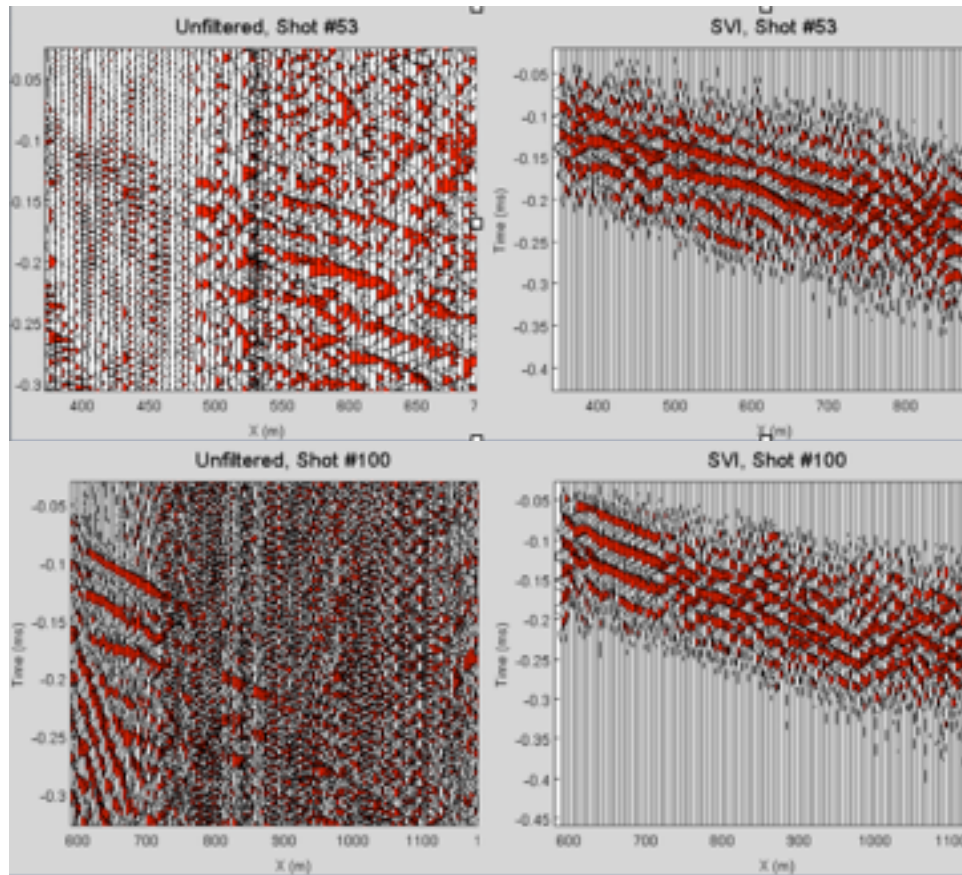


Figure 7: Sampling of Results for SVI, shots #53 and #100

SVI was performed on the filtered seismic data. The result can be seen above in Figure 7. For each trace the SVI had to be muted, both removing the direct wave and isolating any refractions. Additionally, multiple refraction events would have to be isolated and have SVI be performed on them individually. This was not possible to be done on our dataset since there was too much noise to differentiate refractions. The SVI was done as if there were only one refraction event in the data.

V. Conclusions

As can be seen in Figure 7, the SVI only marginally improves data quality. For both the shot #53 arrival and the shot #100 arrival, the SVI does not reliably extract the refraction wave and the result is still too noisy to pick. The strong refraction arrivals still appear, however the need for better picking those events isn't needed. In the shot #53 example the SVI is not able to accurately find first arrivals before 500 meters and after 700 meters while in the shot #100 example the SVI can't find first arrivals after 700 meters where it is needed the most.

The SVI method is a powerful tool for increasing data quality in some situations, however in this situation it is a bridge too far. The amount of noise present in the dataset means we are in effect just feeding noise into the algorithm and getting noise back. Future studies using this data would do well to either change focus (inverting surface waves which are far more prevalent) or by taking the time to do very fine and involved filtering and muting for each CSG individually.

References:

1. Lab Information. (n.d.). Retrieved December 8, 2015, from <http://csim.kaust.edu.sa/web/lab.html>