The Processing of Seismic Data at KAUST Golf by Commercial Software

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ABSTRACT

Reflection waves are a basic and important part in seismic data because reflection carries information of subsurface structures. Imaging the subsurface structure with reflections is an effective method, which is widely used in seismic data processing. The goal of our project is to enhance the signal-to-noise ratio of the data and try to have some basic ideas of the subsurface structure near KAUST Golf club in stacking section.

INTRODUCTION

First, we will introduce this seismic field experiment briefly. We began our field experiment on Oct. 10th, 2015 in front of The Golf Club of KAUST (figure 1). There are totally 240 sources and receivers, and their spacing is five meters.
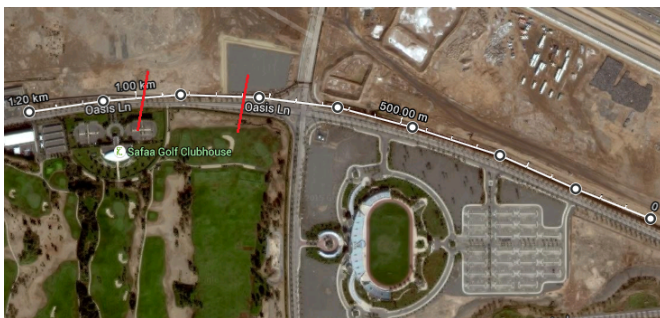

Figure 1: The location of this seismic field experiment, where the red line show the position where faults may exist.

Seismic records contain a lot of information. Some are useful in our processing while some are not. Reflection events are used here as signal and all the other waves are noise that we are not interested in. Figure 2 shows one
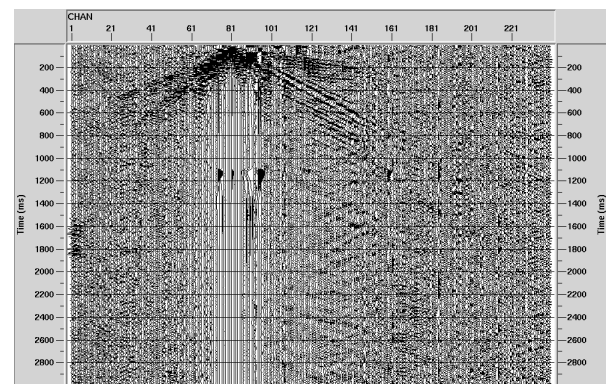

Figure 2: The 81th shots for the KAUST Golf data.

shot gather of the raw data. We can see, there are a lot problems in this data:

- high-frequency noise,
- bad traces,
- surface waves are dominant,
- reflections are hard to see.

PROCESS PROCEDURES

How to get rid of the noise is a big problem. The processing contains three parts, totally eleven steps, to enhance the S/N ratio. And We process the data according to the flowcharts shown in figure (3). Each one will be presented in the report.

Geometry definition, traces Killing and muting

Defining the geometry and correctly filling the trace headers is an important, and often tedious, process. When the geometry and the trace headers are correctly defined and
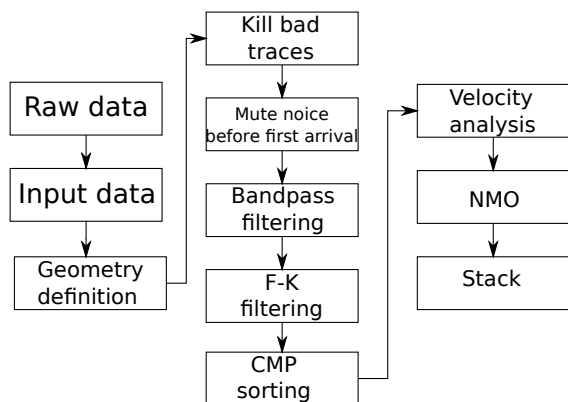
Figure 3: Work flow

Figure 5: The 81th trace after bandpass filtering (5 Hz-80 Hz).

set, spatial and temporal processing steps become possible. Killing noisy traces should be one of the first processes applied to the data. The process of killing means setting all the amplitude values of noisy traces to zero. There are a lot noise before first arrivals, so, it is necessary to mute noises before first arrivals. One of the shot gathers after bad traces killing and top muting is shown in figure 4.
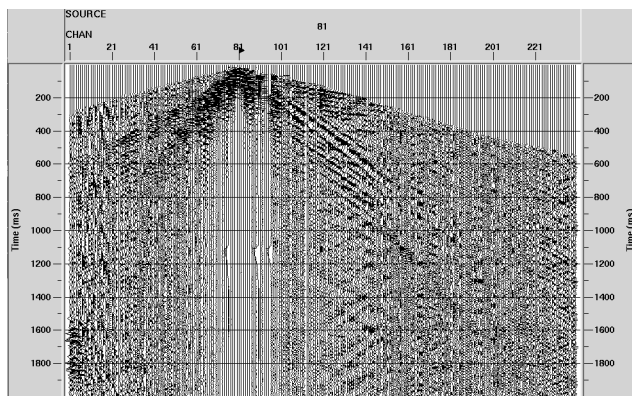

Figure 4: The 81th trace after bad traces killing and top muting.

Bandpass

There is background noise in the data. Background noise and reflections have different frequencies, because background noise can be considered as random values. Here bandpass filtering is applied to attenuate the noise at frequencies other than the dominant frequency of the signal. After bandpass filtering (5 Hz-80 Hz), which is shown in Fig. 7, small wiggles are eliminated. It means background noise has been attenuated.

FK filter

Surface waves constitute noises on seismic records because their amplitudes are significantly higher than those of the body waves we are interested in, when examining
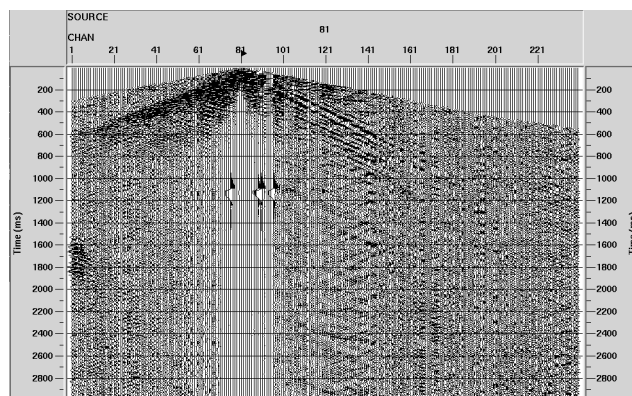
reflection/refraction seismology. The amplitudes of Surface waves decay exponentially with depth. Surface waves are recognized in shot gathers by their slow velocities and high amplitudes when compared to the body waves. According to the velocity of surface waves, we use a FK filter (shown in figure 6) in order to reduce surface waves. Figure 7 shows that the surface wave is reduced; however, there are some artifacts shown up by FK filtering at the abnormal place in the shot gather.

Velocity analysis

All the steps above are processing data in common-shot gather, which means the data is arranged in shot numbers. Using one trace to represent the image point is not good enough. Processing data in common-midpoint gather is a good way to avoid the noise left in our data. In each CMP gather, all the traces represent the same reflectors beneath the common-midpoint.

Reflections will not be correctly expressed on the final stacked section without correct velocity analysis. Velocity analysis is the process by which the stacking velocities of reflections are determined. Here velocity spectral analysis is used. Figure 8 shows the velocity analysis procedure, where we can see it is hard to choose a velocity for the bad reflection information in the CMP gather.

NMO and stack

NMO is the traveltime difference between the recorded traveltime for a reflection of a source-receiver pair with some separation. NMO are applied to data using the velocity filed generated during velocity analysis.

The reflection events are flat after NMO, because the difference of travel time between traces has been removed. The travel times of reflections in traces are now equal to the shortest reflection travel time.

Traces within NMO-corrected CMP gathers are summed vertically (stacked), and the subsequent traces are positioned at the CMP locations. Apply stacking to all CMP

gathers, the result will be a stacking section shown in figure 11.

DISCUSSION AND PROBLEMS

Noise in raw seismic data is a big problem. It may lead to misinterpretations. To solve the problem, enhancing S/N ratio and doing stacking are effective methods. In our processing, eleven steps in three parts are introduced. After every step, the reflections in the data is still too weak. The final result of stacking section does not show the subsurface structures. More processing steps should be applied to get a clear result. The steps include statics corrections, residual statics, multiple reflection attenuation, migration, and so on, but they are beyond the discussion here.

Looking though the data, we have noticed that there are a lot backscattered surface waves. It may be interesting to apply the nature migration of backscattered surface waves to this data.
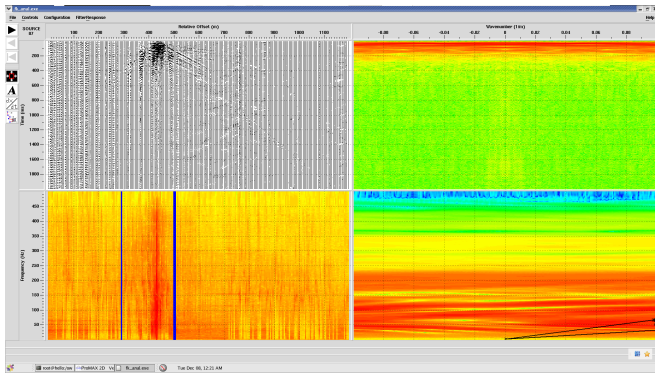

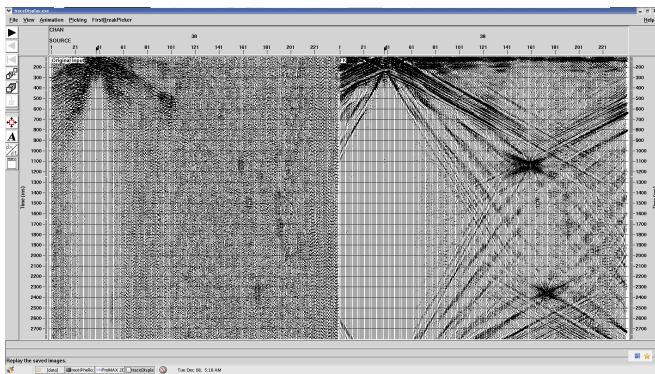Figure 6: A FK filter shown in the right down panel.
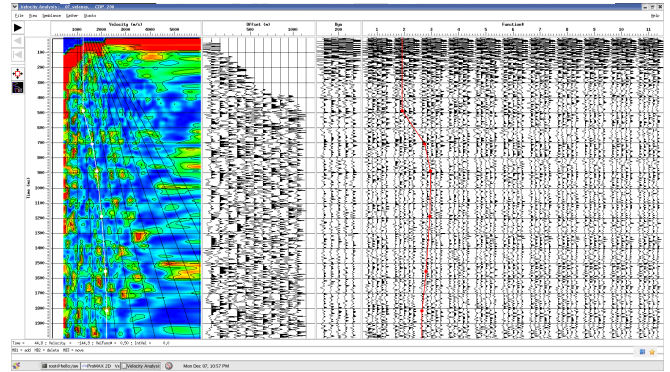

Figure 7: FK asterisk in the trace.
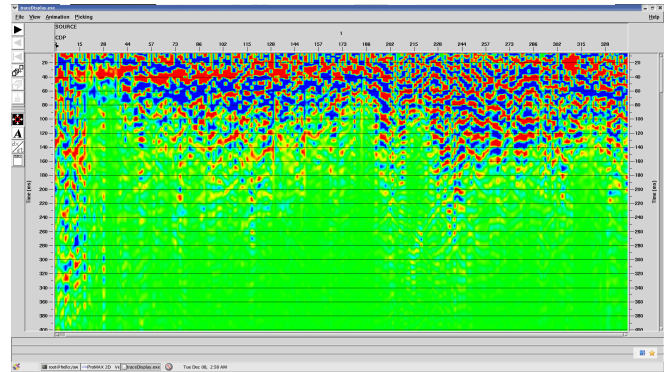

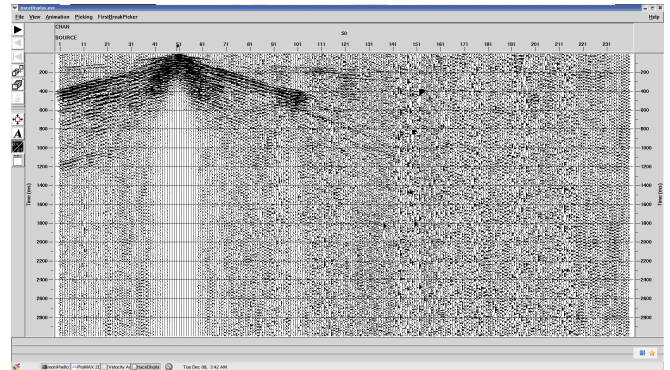Figure 8: Velocity analysis.

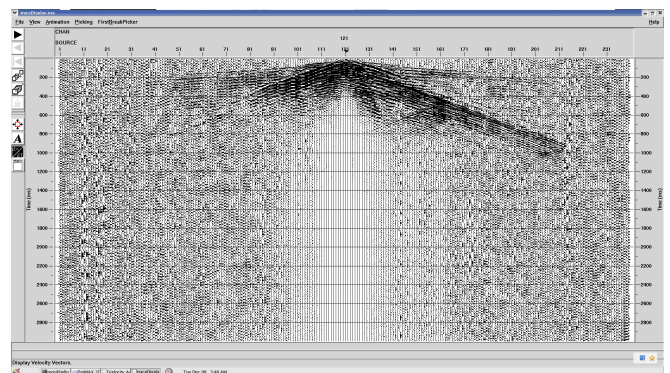Figure 9: The stacked section.

Figure 10: The CRG that shows the backscattered wave.

Figure 11: The CRG that shows the backscattered wave.