Making and using cross-spread domains in 3D seismic processing

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In hydrocarbon research seismic exploration is the most frequently used geophysical method to find subsurface geological structures. However we need to apply numerous processing steps on the raw seismic data till we can get interpretable sections from the field acquisition. An important part of the seismic processing is the suppression of noise – for example ground roll – for the benefit of the valuable reflections. This paper outlines a special gather of the seismic data the so called cross-spread domain. Utilizing this domain as the input of 3D FKK filter we can reach the suppression of the high amplitude noise caused by the ground roll.

The seismic traces could be sorted in gathers by several ways, depending on the desired processing step. There are many types of gathers for example common depth point gather, common shot point gather or common receiver pointgather. A cross-spread collect determined traces. These traces received by geophones located in the same receiver line, and the sources of these traces are shotpoints located in the same shotline. The shotline and the receiver line must be perpendicular to each other. By this sorting we can get a simple fold gather of traces, which is well sampled and the attributes of the traces – such as azimuth or offset – change in a continuous way trace by trace.

To create cross-spread gathers an orthogonal – the geophone lines and the shotlines are perpendicular to each other – 3D seismic acquisition is required. The raw data of such an acquisition was provided for me by MOL Plc. I selected a smaller part of this data to make a cross-spread gather. The sorting was made by the modules of PROMAX Seisworks. Getting to know the modules and parameterizing them were essential parts of my research and were documented in detail.

The established cross-spreads are appropriate inputs for a 3D FKK filter. By Fourier transformation of the data we can analyse the strength of the signals as the function of three variant, the frequency and wavenumbers of the x and y directions. In this FKK space it is easier to separate the seismic events from each other by their velocities. We can distinguish the slowliest ground roll, the faster direct waves and the fastest reflections. On cross-spreads I tested different velocity filters to suppress the noise caused by ground roll without attenuate the valuable reflections. By comparing the same sections before and after the filtering and analysing the differences of them, the efficiency of the filter can be estimated. I reach the best results at far offsets with using the velocity of the direct waves as the parameter of the velocity filter.

To verify the method I fill the traces of the acquisition with synthetic signals. I created four different seismic events: a reflection, a direct wave and a ground roll which consist of two components with different velocities. I also made cross-spreads from the artificial data volume and used them as input of the FKK filter. The filter show similar results as in case of real data, however in the FKK space strong aliasing effect could be noticed, which can make the distinguish of the seismic events more difficult.

As the result of my research I elaborated a workflow on sorting 3D seismic data into cross-spread gathers and I proved that this gather is an appropriate input for 3D FKK filtering. By this velocity filtering method we can attenuate the noise of the ground roll therefore obtain a better signal to noise ratio and better seismic sections at the end of an overall seismic processing before the interpretation.