Z-99 Review of Specific Parameters in High Resolution Seismic

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Abstract

When designing, acquiring and processing high-resolution seismic surveys, some parameters and milestones, which may not be critical for traditional medium-to-deep targets, must be looked at carefully in the case of shallow targets. This paper will detail some of these different important steps, with examples of 3D high-resolution seismic applied to mining development which offers more effective mine management through the detection of faults with a throw of a few meters, and mini 3D seismic for shallow gas risk detection surveys.

Acquisition parameters

The basic geophysical parameters are determined using the well-known vertical and lateral resolution equations. The following example describes a specific request made to image both very shallow and medium depth targets. The aim of the survey is to detect anomalies due to the presence of gas, from the surface down to a depth of 1500m, prior to the positioning of a deep drilling platform. The first 400m concern a surface around the center of the area and this is processed using a high-resolution squared patch of approximately 500m x 500m on the surface, with a bin size of 7.5m x 7.5m in the subsurface. The deeper part of the investigation must cover an area with a radius of 1500m around the center of the area. The coverage should include all couples with an offset up to 1500m, in order to build a convenient fold order in this range, on a bin size of 15m x 15m.

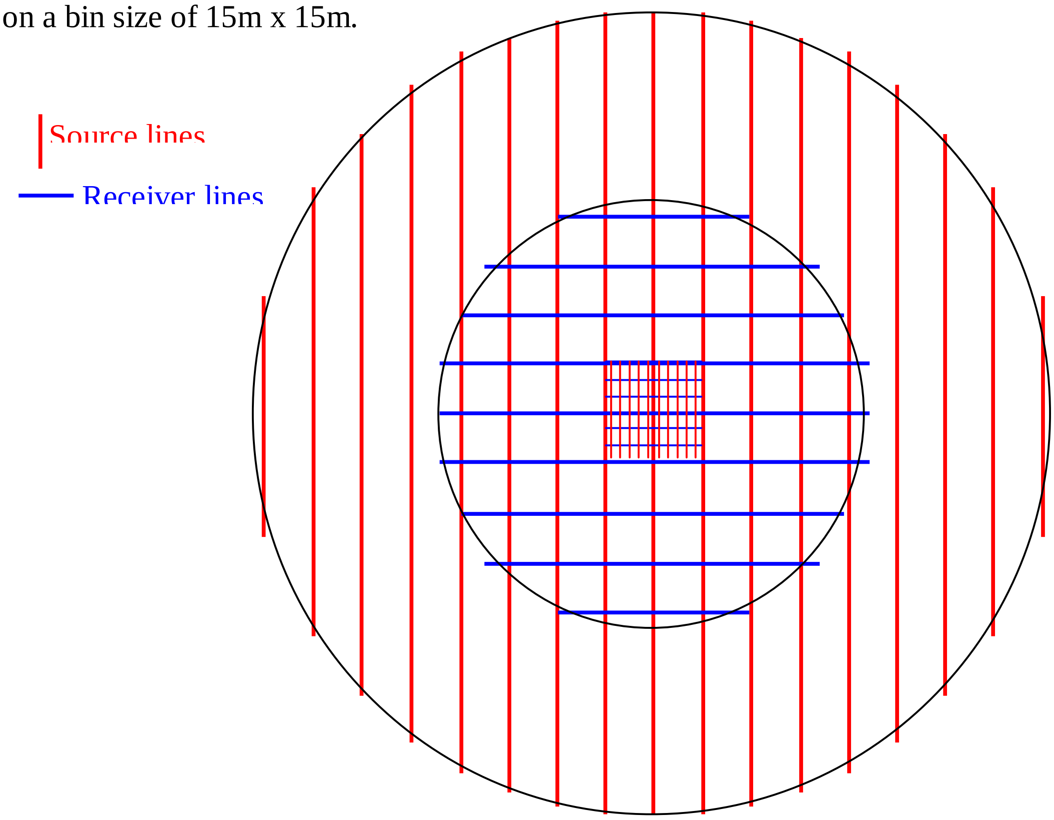

Figure 1: Mixed 3D grid to image very shallow and medium targets

Source and receivers

When a seismic source is selected for a particular survey, little attention is often paid to the expected geology, resulting in source overkill. Large source volumes are often unnecessarily deployed, resulting in deep penetration but also a major loss of the high-frequency components and hence resolution. Dynamite is, as an initial approach, the best source because it offers a complete frequency spectrum, from a few hertz to more than 500Hz. However, the weathering zone acts as a filter and the depth of the charge could be a limiting factor. It could create a ghost effect as in dual-sensor OBC acquisition and degrade the frequency spectrum. For vibrators, good control over the frequencies emitted will be limited by the uncontrolled surface conditions.
On the receiver and recording side, the geophone type and tilt, the sampling rate and recording filters are some of the parameters, which need to be taken into account in order to preserve the HF content of the seismic data.
Arrays also deserve careful attention. Single vibrator arrays are already possible even with medium-range targets with new heavy high-resolution models, but single sensor seismic channels, which will be the norm in the future, are still not cost-effective for group interval over 10m.

Positioning accuracy:

When looking at frequencies over 100 Hz, the traditional metric accuracy is no longer sufficient. In the case of arrays, accurate positioning of all elements in the array is also necessary.

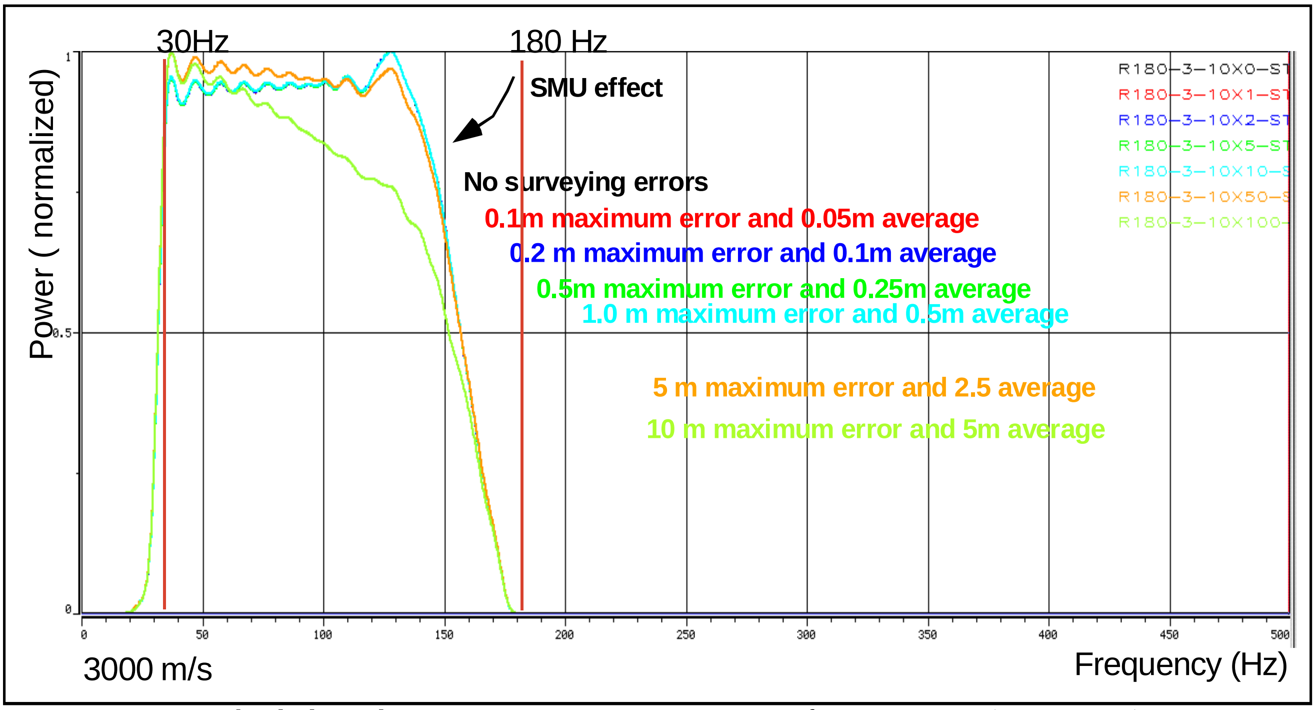

Figure 2: Amplitude decay due to positioning error on a 30-180 Hz frequency range (V = 3000m/s)

Processing

To achieve resolution on a meter scale, it is of paramount importance to master control over the static correction, noise filtering and a very fine velocity analysis paying particular attention to the mute stretch effect.

Statics: good primary static control on the near surface is obtained by detailed up-hole surveys and a modeling of the weathering zone by using first break picking computed with a generalized linear approach. The basic first model is updated by means of an inversion method.

Noise removal: either surgical mute or adapted 3D F-Kx-Ky filters can remove the greater part of ground roll noise which affects most land seismic data.

NMO: The example below shows the shallow part of a marine streamer stack with the full streamer length data on the left, and only the first 1000 m of streamer on the right, showing a better preservation of the high frequencies.

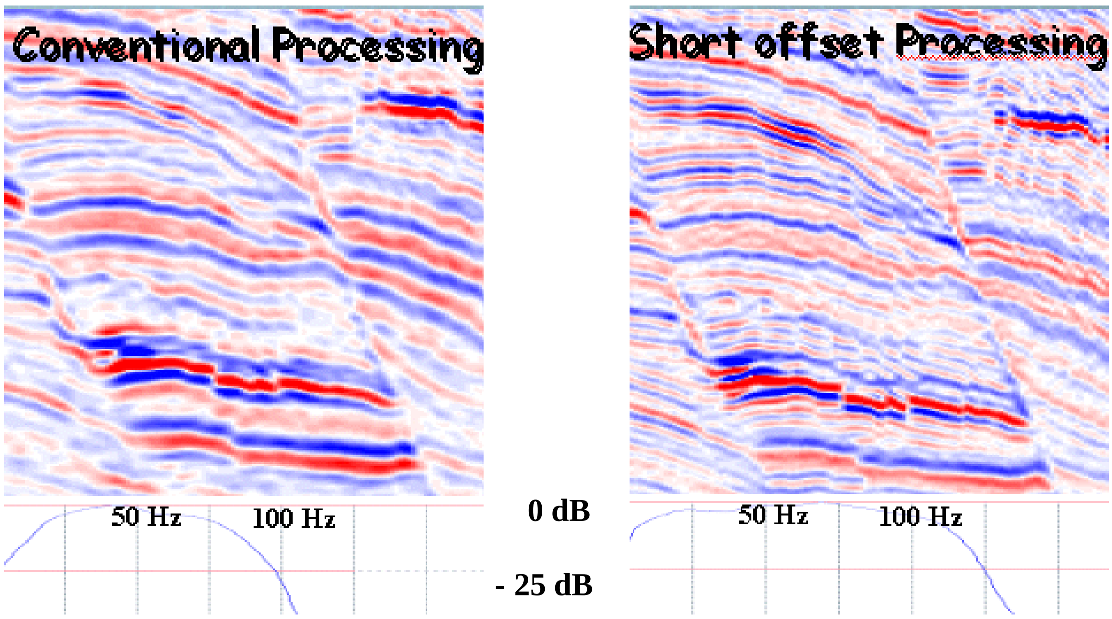

Figure3:Comparison of shallow data with all offsets on the left and only short offset on the right

This is explained by the comparative curves below showing the influence of NMO errors.

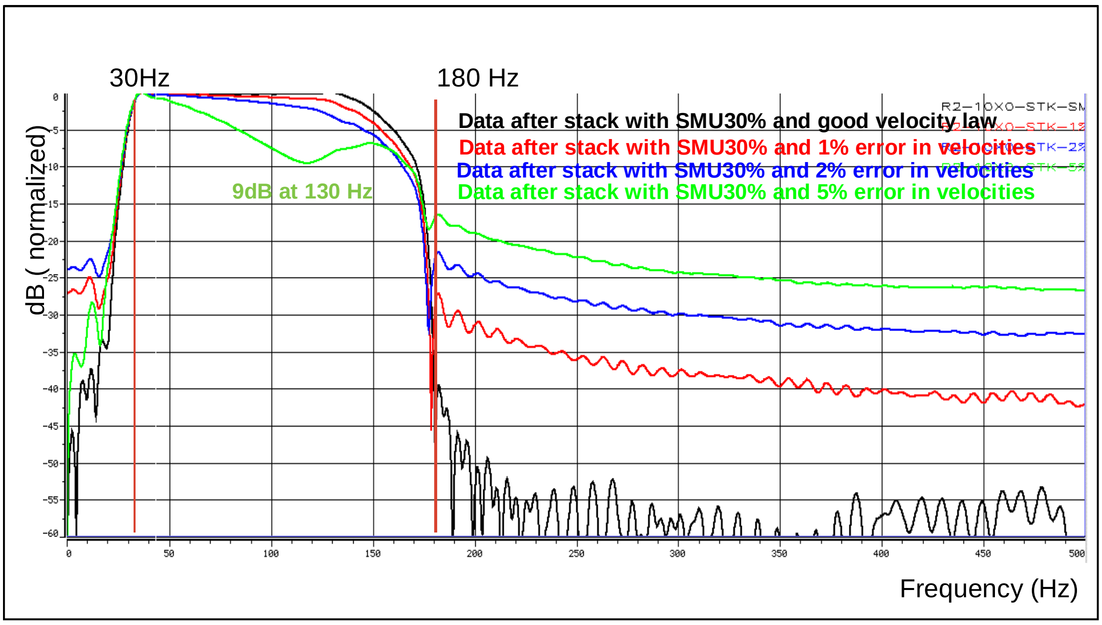

Figure 4: Effect of the accuracy of NMO velocities after stack on a 30-180 Hz linear sweep

Semblance processing: the application of new seismic software used in the oil industry can also accurately highlight mine-planning problems. This program produces a volume of « semblance » coefficients for each sample of the 3D block. This information is loaded onto a workstation and visualized in the same way as the seismic amplitude. The example in the figure below shows a clear view of anomalies on the southern part close to the main fault that were invisible on the traditional horizon amplitude maps.

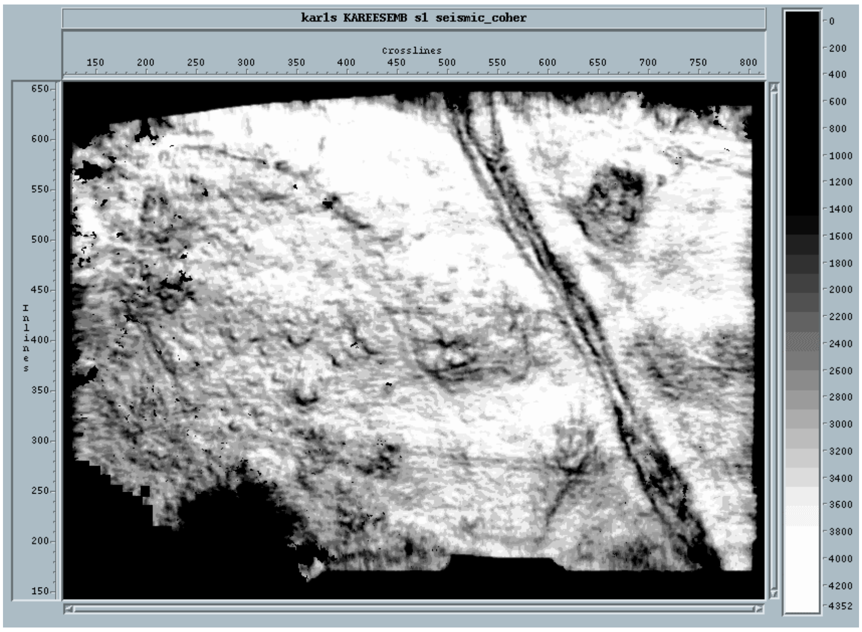

Figure 5: Semblance on the target layer

Conclusion

High-resolution seismic first and foremost requires good terrain conditions and perfect control of all seismic parameters. New processing techniques have already shown interesting geological features, which were invisible with previous processing tools. In the near future, a combination of surface and VSP seismic could also help enhance the seismic bandwidth.

References

How 3D seismic can help enhance mining? M.Larroque et al, EAGE2002 Florence