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Recommended operating guidelines for 3D seismic derived seabed imagery

1. Data acquisition

It is not envisaged that the reader will be involved in the commissioning of 3D seismic surveys since they are essentially multi-million dollar projects for the purpose of hydrocarbon exploration, development and production. Although not focused on seabed habitats, however, 3D seismic surveys can provide high-resolution spatial data often at 12.5 m or 25 m spacing across extensive areas and can provide morphological information, extremely useful for habitat mapping. Given the high cost of these surveys, utilising them for secondary purposes makes economic sense and they have increasingly been used for seabed and top-section geohazard assessments in recent years. The issue as to the suitability of using 3D seismic in lieu of high-resolution 2D surveys for geohazard assessment is discussed in Bulat and Long (2006). Industry experience in deep-water areas (>500 m) is that image quality is comparable to, if not better than, swath systems. In shallower water depths, however, the ability to image the seabed and near seabed section is dependent upon the details of the acquisition design. The potential user of the 3D survey will need to assess the suitability of the survey for their particular purpose.

2. Data interpretation and visualisation

A fulsome description of 3D interpretation is provided in Brown (1996). 3D seismic data are provided as data volumes that are loaded into seismic interpretation workstations. The interpretation software permits the viewing of arbitrary lines and time slices through the seismic volume, as well as viewing of standard lines and cross-lines. Care needs to be taken during loading, however, to ensure that the data set in the shallow section hasn't been degraded in order to optimise the visualisation of the deep section, as this results in 'terracing' artefacts (Bulat 2005).

Horizons are picked manually on a subset of the data and then propagated throughout the rest of the volume using auto-picker software. Which part of the reflection wavelet to pick is an empirical decision based on the quality and coverage of the resulting 3D seismic horizon, as processing and data loading induced artefacts may affect the most obvious lobe to use. Some experimentation and horizon quality control will be required to obtain optimum results.

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The resulting 3D horizon often contains a wealth of information, as is seen when rendered as shaded-relief images (Bulat & Long 2001, Long *et al.* 2004). Many software packages provide shaded-relief illumination where local gradient and therefore morphology is picked out by generating false shading assuming a light source of a particular azimuth and inclination. Shaded-relief imaging of surfaces emphasises subtle changes in gradient and is thus ideal for morphological feature mapping. Shaded-relief imaging can be used to suppress linear noise by the suitable choice of illumination direction (Bulat & Long 2001, Long *et al.* 2004).

3. Image artefacts and interpretation

When interpreting a seabed image derived from 3D seismic data, artefacts need to be considered. A full discussion of the artefacts identified during the compilation of the Faroe-Shetland Channel seabed image is presented in Bulat 2005. The following artefacts were identified from that study and are typical for 3D surveys in general:

- Survey boundaries

  It is often difficult to match adjacent or overlapping surveys in the shallow section. This is often owing to different static shifts generated by minor processing errors in the 3D seismic. It may be necessary to pick different parts of the wavelet generated by a reflector on adjacent surveys to achieve maximum coverage. This will generate a time shift that will result in an abrupt dislocation on the image. Usually, the boundary is obvious and does not detract from the value of the image. Some surveys are in fact mergers of different surveys that have been reprocessed together. The reprocessing may concentrate on aligning deeper events and so be imperfectly matched in the shallow section, resulting in a boundary artefact.

- Terracing

  During loading of the seismic volume into the workstation, common practice has been to scale and clip the seismic amplitudes to enhance the appearance of deeper reflectors that were typically of much lower amplitude than the seabed reflection. This causes the auto-picker to generate ‘terraces’ instead of smooth interpolation of the seismic horizon, so reducing the quality of the final image.

- Survey footprint

  Survey footprint is coherent noise that is orientated along the direction of survey acquisition. It manifests itself as static shifts between adjacent lines. These can be quite marked in the shallower section. All offshore 3D seismic surveys exhibit these artefacts, which are not constant in time between reflectors. To some extent the impact of survey footprint on the shaded-relief image can be reduced by placing the illumination direction along the acquisition direction.

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- Shallow water degradation (<500 m water depth)

Depending on the acquisition and processing design of the survey, the quality of the seabed image derived from 3D data may deteriorate owing to increased noise levels as the water depth reduces.

- Processing artefacts

Seismic data processing is complex and is optimised for particular objectives decided by the client. If the client does not consider the seabed important, then the processing house will probably not spend much time correcting minor problems at this level; e.g. false pinnacles observed on seabed images generated as a by-product of a processing step designed to improve imaging at the target depths for the survey. To identify artefacts of this type requires access to the original seismic volume from which the seabed image was created.

All seismic surveys are designed to image specific target depths. The parameters chosen to achieve the survey objectives may or may not be suitable for imaging the seabed as well as near seabed events. It is important to properly understand the vertical and horizontal resolution of the 3D seismic imaging as this will impact on the interpretation of the resulting seabed image. Most oil exploration 3D seismic surveys use seismic sources with peak frequencies of approximately 30 Hz, giving a vertical resolution of 12.5 m. In these circumstances beds thinner than this thickness will not be resolvable. Bulat (2005) gives an example of the impact this has by comparing a TOBI (Towed Ocean Bottom Instrument deep-towed side-scan sonar) high-frequency source image of steep-sided downslope channels in the Faroe-Shetland Channel, which are partially infilled with contourite sands, with the seabed image generated from 3D seismic scans over the same area. The contourite sands are not imaged on the 3D seismic (the thin sands are effectively invisible to the 3D seismic derived image) and instead the steep-sided channels can be followed further upslope. In deep-water areas many operators now design their 3D seismic surveys to image the seabed and near seabed, as well as the deeper exploration target, in order to remove the requirement for additional geohazard surveys (Bulat & Long 2006). These surveys achieve greater vertical resolutions of 6.25 m. The horizontal resolution of 3D seismic is defined by the original 'bin' size of the survey; typically 12.5 m, but older data are often 25 m. Thus, features less than this size will not be well imaged.

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4. Guideline summary

Although there are some researchers generating high-resolution 3D seismic data sets, most 3D seismic surveys are obtained for hydrocarbon exploration. They therefore tend to use low-frequency sources and lower temporal and spatial sampling. Thus, when use an existing 3D survey, the following procedure should be followed:

- Check the suitability of the 3D survey for the proposed purpose and determine the effective vertical and horizontal resolution of the survey;
- Ensure volume is loaded to the full resolution and is unclipped at the seabed;
- Identify optimum seabed pick to achieve the most consistent result;
- Generate and ensure quality control of the 3D seismic horizon;
- Generate shaded-relief image of the seabed;
- Identify artefacts and consider their impact on the interpretation. This may require re-examination of the 3D seismic volume to decide whether some features seen on the image are artefacts or not;
- Produce interpretation bearing in mind the resolution of the data.

References

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