A FLEXIBLE VHR MARINE 3D SEISMIC METHOD FOR SMALL-SCALE SITE SURVEYS IN SHALLOW WATER

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In the early 90s the Renard Centre of Marine Geology (University of Gent) demonstrated that it is feasible to acquire VHR 3D seismic data in a modest and cost-effective way, thereby entering the world of small-scale geological structures. Despite the good results, the data were not of the optimum quality due to a number of technical shortcomings in the field system. Re-dimensioning, adaptation and optimisation of the 3D acquisition method were required. In the framework of the EC MAST3 Project 'Very high resolution marine 3D seismic method for detailed site investigation' a new compact, flexible 3D acquisition system was developed for studies in shallow water (< 30m), providing limited penetration (<50m) and aimed at target sites of limited areal extent (100x100m roughly).

The 3D array consists of two inflated modular wings, each consisting of 3 slim catamaran-shaped frames, attached to a central RIB (Figure 1). The 2m wide and 4m long frames provide the spatial control for the spread of 8 short dual-channel streamers (2m channel and streamer spacing). The surface-towed frames are kept under air pressure (~1bar) which allows convenient deployment and recovery (inflation and deflation), even on small vessels. The use of a modular system allows to vary the total width of the acquisition system, simply by increasing or decreasing the number of modules and streamers. The 3D acquisition system can be deployed from small to medium-sized vessels. In protected waters (harbour areas, rivers, canals and lakes) the system can be also used autonomously.

A first test survey was carried out with the new 3D array in Sept. 1999 on the Schelde river. The target consisted of a small clay diapir (60 m diameter of 60 m, 4 m vertical amplitude) near Antwerpen, marked by numerous concretions (so-called 'septaria'), with a diameter of 0.5-1 m and a thickness of 0.2-0.3 m. Positioning during the survey was done using a short-range kinematic DGPS system (dual frequency receiver, UHF data link) resulting in real-time (x,y,z) positions with cm accuracy. The antenna was installed on the source frame (Seistec), thereby further minimizing relative positioning errors.

A dense network of 48 seismic profiles was recorded over the diapir (16 kHz sampling rate), each shot generating 16 traces in a band 7 m wide along the tracks (shooting rate 0.5 s). Theoretical line spacing was 6 m in order to assure overlap in the subsurface spatial coverage. To keep the array well stretched the tracks were sailed against the current, alternatively forward and backwards, the latter simply by decreasing the speed. This resulted in a variable vessel speed, which made accurate steering very difficult. The acquisition was carried out with a bin size of 1 meter - the depth of the target being very shallow, this would adequately oversample the first Fresnel zone for an average signal frequency of 2 kHz.

Shot and receiver coverage were calculated taking into account the ship's movement. Vertical corrections for tidal amplitudes (up to 6 m) were carried out after NMO correction. Additional processing included bandpass filtering, agc and deconvolution. The stack coverage (1x1 m bin size) was generally quite good (average 30 traces/bin), becoming somewhat less towards the margins. The quality of the stacked data is very good (Figures 2 & 3). The lower part of the diapir shows a large number of strong reflectors, which were a lot weaker and less coherent on earlier data. Time slices also showed an improved resolution, with a clearly defined concentric reflector pattern growing towards the base of the diapir. Although the upper part of the diapir remains largely disturbed, some weak internal reflectors can now be observed.

Certain strong reflectors on the time sections are marked by diffraction hyperbolae. The latter can most likely be related to the large concretions (or perhaps clusters of concretions) in the clay layers. Up to now these were only observed on analogue recordings. The limitation of the sampled frequency band (max. 1400 Hz) probably explains the absence of these concretions on former 3D data. The broader frequency range of the new acquisition array has resulted in a higher imaging resolution which allowed to observe the diffraction hyperbolae on the seismic data. The stacked data still display some high frequency variations. The latter is most likely related to small errors in the positioning of the acquisition array. Indeed the strong tidal currents are likely to have caused some amount of streamer movement resulting in a deviation of the supposed theoretical (straight) streamer position.

Fig. 1. Installation of the 3D seismic acquisition system on the Schelde river

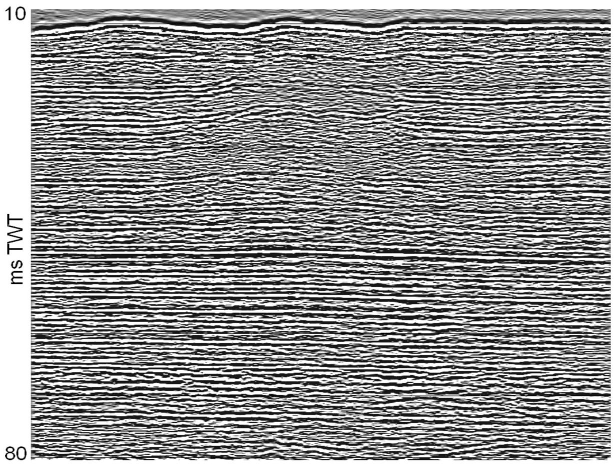

Fig. 2. Time section through the central area of the Schelde diapir. Profile length 140m.

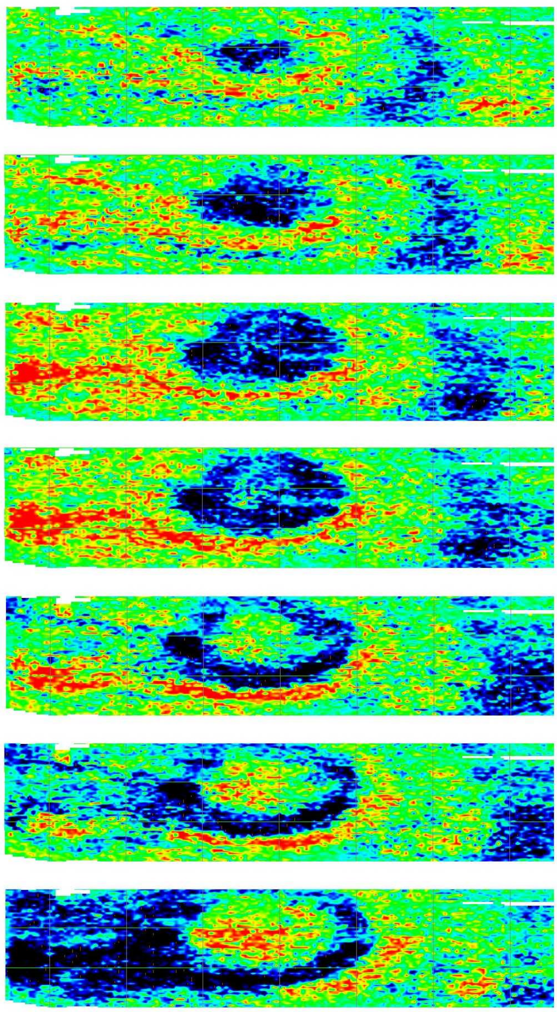

Fig. 3. Time slices (10cm int.) through the lower part of the diapir. Area dimensions 140x60 m.