“Sparse 3D” Acquisition; an efficient exploration technique  
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Introduction

BG International acquired the Sirte123-1 and Sirte123-2 licences in Libya, EPSA IV-Bid Round 2. The licence agreement was signed in December 2005. Since this time BG Libya (BGL) has been planning and executing the first phases of its work programme – a seismic acquisition commitment.

Sirte licences123-1 and 2 cover an area of 5,000 km² and contain legacy 2D seismic data of various vintages and 8 wells. The seismic data is currently being reprocessed ahead of the proposed new acquisition programme.

Figure 1: Sirte123-1, 2 Licence locations

BGL’s strategy for these licences from the start has been to try to undertake an extensive seismic campaign as early as possible in the 5-year licence term. The acquisition of 3D seismic early in the life of the licence is expected to provide the best chance of creating new play concepts that previous explorers may have missed. BGL also faces the same challenges as other International Operating Companies (IOCs) in completing exploration programmes that fully evaluate the potential of the licences and in a success case, the completion of a field appraisal and development plan, within the 5 year licence period.

The main target horizon is the Cretaceous age Sarir sandstone which is a proven and prolific hydrocarbon reservoir (eg in the nearby Sarir and Messla oil fields). A number of potential play types have been recognised including tilted fault blocks, horsts and stratigraphic pinch
outs onto basement highs. Some of these plays are illustrated on the legacy seismic line shown below.

![Seismic line showing Sari interval](image)

**Figure 2 – Example 2D seismic line from the block showing Sarir interval**

BGL has sought to utilise the area of coverage benefits provided by 2D data with the technical benefits of 3D in order to fully evaluate as much of the licences as possible. Thus BGL has opted to acquire a modified ‘sparse’ 3D design for the seismic survey, ensuring that the 3D design is optimised for the target objectives. This should deliver the broad licence coverage required and also the data quality required to recognise and drill potentially subtle features. A sparse 3D survey will also provide schedule and cost efficiencies when compared to a standard programme comprising of a regional 2D infill survey followed by a detailed 3D survey.

By adopting this strategy early and by working co-operatively with NOC, seismic contractors, and other IOC’s, BGL were able to acquire a test line jointly with Occidental in April 2006 (only 4 months after the PSC signing), utilising a NAGECO crew who were in the area. This has provided BGL with a modern dataset that has been crucial to the modelling and optimisation of the survey design.

**Area Scope**

The proposed 3D survey outlined in Figure 3, will be targeted to cover the basement-high margins present both to the NE and SW of the licences, which are thought to have a major influence on the distribution of the non-marine Sarir sandstone and also provide opportunities for both structural and stratigraphic trapping. The final survey outline will be controlled by the required aperture distance for the full-fold, fully migrated dataset, but is expected to cover an area in the order of 3,000km².
**Design Work**

Initial work was done by BGL in conjunction with ECL. The key parameters used to define the proposed sparse 3D design were: line spacing, shot-point interval and sweep length. Spatial sampling studies using the available well control indicated a 25m binsize would be sufficient to sample up to 15 degree diffraction tails up to 60 Hz and that given the good data quality, higher angles would be recoverable by interpolation. The generally low formation dips in the area would support this. The offset modelling showed that initial ideas of 650m shot line spacing would not provide enough fold (i.e. approximately 4 fold at the Base Oligocene marker – Figure 2), and the shot line spacing had to be reduced to 350m. A symmetrical orthogonal line layout design was chosen (after Vemeer 1998) to provide better offset and azimuth distribution for multiple attenuation.

Subsequent testing (using Spectrum as contractor) has been performed on a BGL test line which was acquired to finalise design work for the 3D prior to tender and planning. This was acquired over a 10km length with a shot interval of 12.5 m. Simultaneously, a walk-away test was run at right angles to the main line. This confirmed the area (at least in the east) was likely to benefit from low noise levels. That this low noise probably applied to the whole area was supported by integrating discussions with other operators, review of satellite imagery and reconnaissance of the site.

The majority of the tests conducted on the 2D test line were undertaken to resolve the level of source effort required. The majority of tests were focussed on the sweep length and number of sweeps required for the survey as these were deemed to have the greatest impact on the cost and duration of the survey. The following tests were run:

- Tests 1-5; tests of sweep length 8-16 sec (Fig 4), sweep frequency 6-72 & 6-96 Hz.
- Test 6; analysed source efforts with 2 Vibrator (Vib.) versus a 4 Vib Array
- Tests 7 -10; tests of a cross-line and box Vib. Source Arrays for noise analysis

These tests were compared and processed using a limited offset technique to mimic as closely as possible the offsets expected in the 3D design. These tests led to the final optimum design, as summarised below:
Summary of design:

- Shot line direction: north-east to south-west
- Shot and Receiver Line spacing: 350m
- Shot and Receiver Group interval: 50m
- Geophones per group: 12 (in a 3x4 array)
- Sweep frequency: less than 6-96 Hz
- Sweep Length: 8 sec
- Vib. Source array: 4 vibrators in a line

Figure 4 – Comparison between 12 sec sweep with 8 sec sweep

Summary

With the seismic and rig markets being very tight in Libya, and in light of the 5 year EPSA-IV licence period, any chance to fast-track the work programme should be examined.

For BG Libya, the ‘sparse’ 3D acquisition design discussed in this paper should allow acquisition of high quality 3D data, whilst retaining an efficient survey acquisition schedule and pricing. Use of the existing 2D data and acquisition of a test line ahead of the survey design was a great advantage in the design optimisation, and should be considered as best practice in ‘sparse’ 3D design.