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Shallow marine seismic survey over Saracen Bank, offshore Sabah

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Abstract: After the P.S.C. for the offshore Block SBI (7746 sq km) between Sabah Shell Petroleum Company, Pecten Malaysia, PETRONAS Carigali as Joint Ventures and PETRONAS was signed in mid 1987, a fairly comprehensive Exploration seismic programme of over 8000 km of 2D and nearly 300 sq km of 3D data was carried out over the Block. Due essentially to very shallow water depths of less than 10 m, the Saracen Bank area, which is located some 80km west of Kota Kinabalu, and includes some corals, remained uncovered by these conventional surveys. This paper describes the key aspect of the survey preparation, the seismic programme and acquisition techniques, and discusses some of the results of a unique marine seismic survey over the offshore shallow water area. The environmental impact of this successful survey was closely monitored before and during this project and the results recorded.

INTRODUCTION

After the Production Sharing Contract for the offshore Block SB1 (7,746 sq km) between Sabah Shell Petroleum Company, as Operator for a Joint Venture between Sabah Shell, Pecten Malaysia and PETRONAS Carigali and PETRONAS was signed on 16/07/87, comprehensive 2D and 3D marine seismic programmes were acquired over most of the area. However the Saracen Bank area, an offshore shallow water area which includes reefs, remained uncovered and unexplored by these conventional deep water marine seismic surveys, due to very shallow water depths. This paper describes the acquisition of seismic data to explore the Saracen Bank which required a very special shallow seismic technique using telemetry equipment called Digiseis. A special crew was mobilized which included a "Mother" vessel, (base and command centre) and several specially equipped craft to carry the seismic equipment and personnel.

SURVEY PREPARATION

As advance preparation for the specialized shallow marine seismic survey, a reconnaisance hydrographic survey was carried out in 1988 by Sabah Shell's Topographical Survey department. Water depths in the area were known to range from 50 feet off the reef to almost zero on the reef. Depths profiles were measured along a one kilometer by one kilometer grid using a small shallow draft vessel equipped with echo sounder and positioning system. This survey however did not fully indicate numerous very shallow coral pinnacles which occur to the side of the traversed lines. The resultant hydrographic sounding map, together with weather and wave height data, were provided to the

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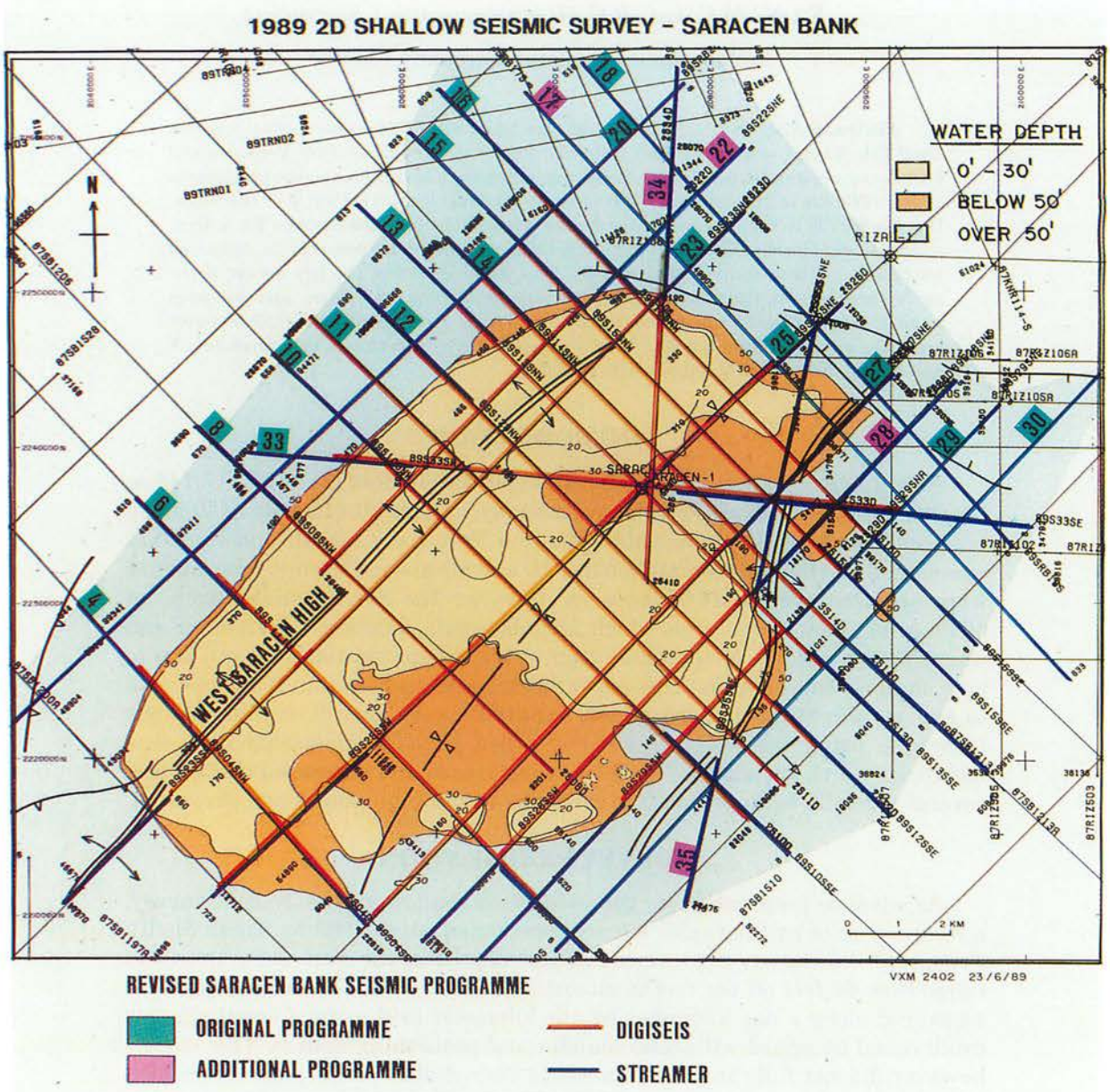

Figure 1: Preliminary interpretation of the Saracen Bank (with the modified programme)

contractors during a pre-tender briefing. In that meeting, contractors were informed about Sabah Shell's environmental and safety programme and the specific requirements for this specialized survey. The use of dynamite as a seismic source was stated to be unacceptable in this potentially environmentally sensitive area. An environmental impact assessment survey was also carried out for this survey.

SEISMIC PROGRAMME

A seismic programme of 250 km consisting of 18 lines on a 2 by 2 km grid covering the reef was initially selected (Fig. 1). The lines tied in with the pre-existing (1987) conventional marine seismic lines surrounding the reef. The programme was later modified during the acquisition phase, to reflect the latest understanding of the structure as field processing and quick-look interpretation proceeded.

ACQUISITION TECHNIQUE

A contract was awarded in March 1989 to Laiman Corporation/Western Geophysical hereinafter called Contractor. Two modes of operation were selected for this survey; (i) a Digiseis telemetry acquisition technique for areas with water depths shallower than 30 feet using M/V "Trident", a deep marine seismic vessel, as mother vessel and M/V "Ranger II" as a shallow draft (< one meters) shooting pontoon. (ii) a shallow streamer method using a shallow draft seismic vessel, (< 3 meters) M/V "Western Orient", for areas with water depths in access of 30 ft.

For both surveys Contractor's high pressure airgun arrays were used as energy source (410 cu inch on the "Ranger II" and 1040 cu inch on the M/V "Western Orient")

SURVEY PROGRESS AND ACQUISITION PARAMETERS

After the initial start-up period, the crew achieved a satisfactory production rate of 3.5 km per day. On board processing using Contractor's Field Auxilliary Computer Equipment (FACE, Micromax) system was applied to derive the optimum acquisition parameters during the early part of the survey. A test line, line 89SRB 14, was acquired to analyse various shooting configurations (one pop per shot point, two pops per shot point at the same surface location and two pops per shot point, 12.5 meters apart), and the required number of channels (96 versus 120). 120 Channels and 2 pops per shot point (12.5 meter apart), were selected as the initial acquisition configuration (See Fig. 2A). Later tests on the Sabah Shell VAX computer, using a median stacking technique, showed that 96 channels were probably sufficient (See Fig. 2B). This reduction in the number of channels increased the daily production

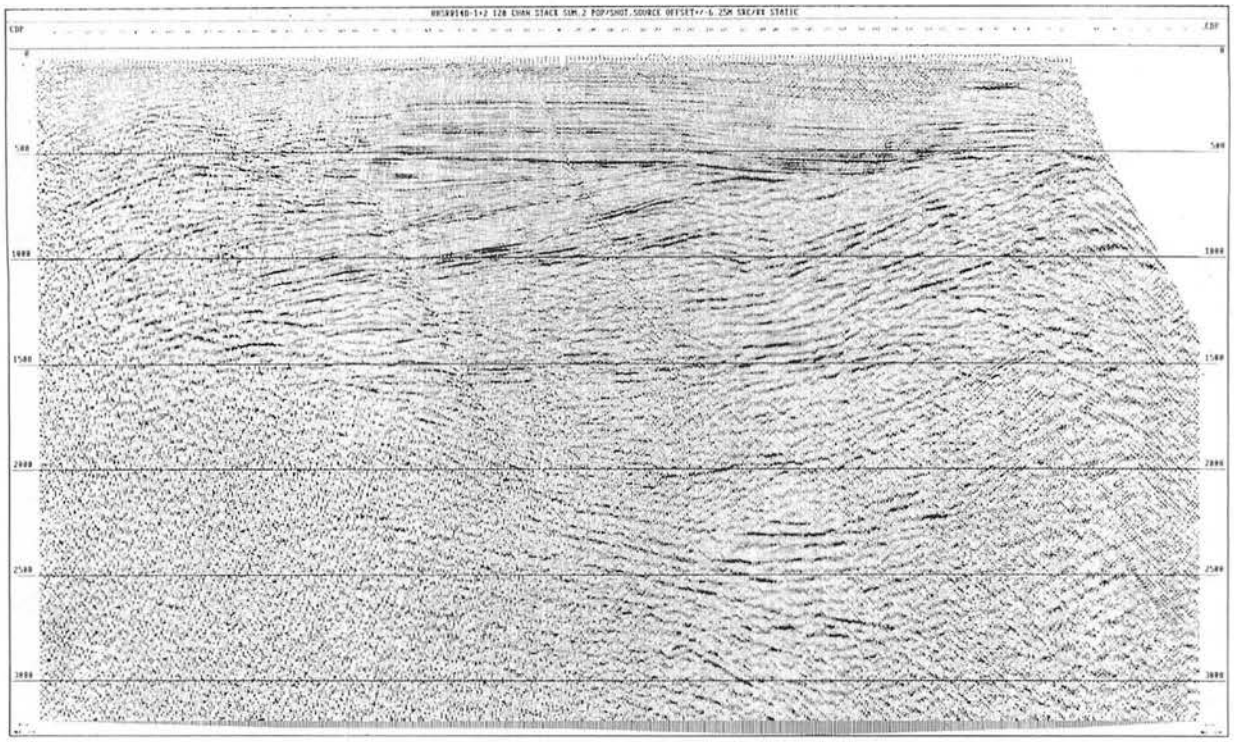

Figure 2A: Brute Stack, Line 89SRB14 (Pass 1 + 2, 120 channels)

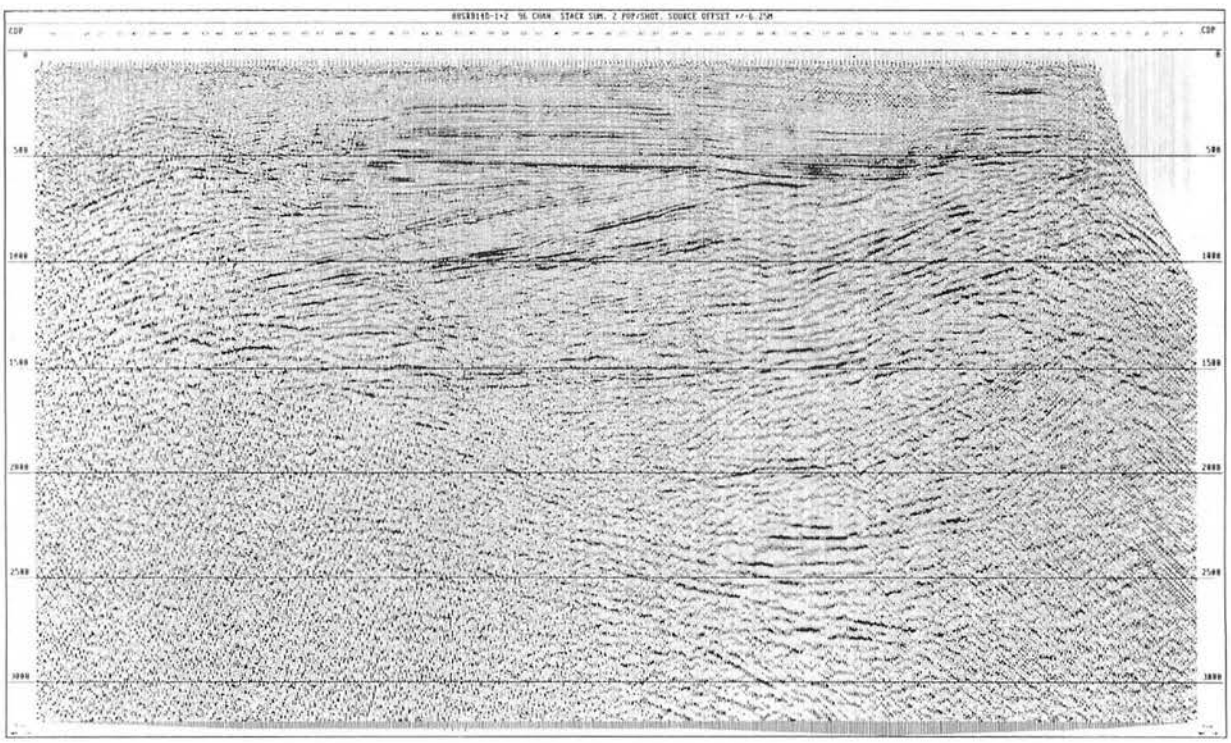

Figure 2B: Median Stack, Line 89SRB14 (Sum Pass 1 + 2, 96 channels)

significantly. (See production chart shown as Fig. 3.) An overview of the acquisition parameters for the various parts of the survey is given in Table 1. Data quality was encouragingly good and showed penetration and continuity below 2.5 seconds. (Fig. 4)

Table 1: Overview of acquisition parameters for various parts of the survey

	Test line (SRB 14)	First Part of Programme	Second Part of Programme
Number of channels	120	120	96
Receiver spacing (m)	25	25	25
Number of passes	3	2	2
Shot point spacing (m)	25	25	25
Eff. shotpoint spacing (m)	25/12.5	12.5	12.5

PRELIMINARY INTERPRETATION

On board the mother (recording) vessel, the FACE system was used to process data to a brute stack stage during the entire survey. Brute stacks of the acquired data were obtained within 24 hours of acquisition and the results were transmitted by Fax to the Sabah Shell office in Lutong (Miri). Preliminary interpretation showed that the Saracen Bank was underlain by two positive trends separated by a synclinal area (Fig. 1). The old well Saracen-1, drilled in 1961 without seismic, is located within the synform and as such probably represents an inconclusive off structure test (Fig. 4 shows a "Brute" stack section of line 89SRB 33 channels). The positive axis to the west forms the northeastern continuation of the West Saracen High. The other positive axis to the east, trending approximately NS, is a buried ridge possible on trend with an oil discovery to the south.

Based on this preliminary interpretation, the seismic programme was modified. Additional lines in the north were included in the programme and lines in the seemingly less prospective southern corner were reduced or shortened. The final programme consisted of 20 lines, totalling some 232 km.

"Dynamic" update to the seismic programme during acquisition illustrates the cost effective nature of such specialist survey in a remote area.

SURVEY TIME AND ACQUISITION COSTS BREAKDOWN

Table 2 represents the seismic performance indicator of the Saracen Bank survey whilst the survey time and acquisition costs breakdown is shown in Fig. 5.

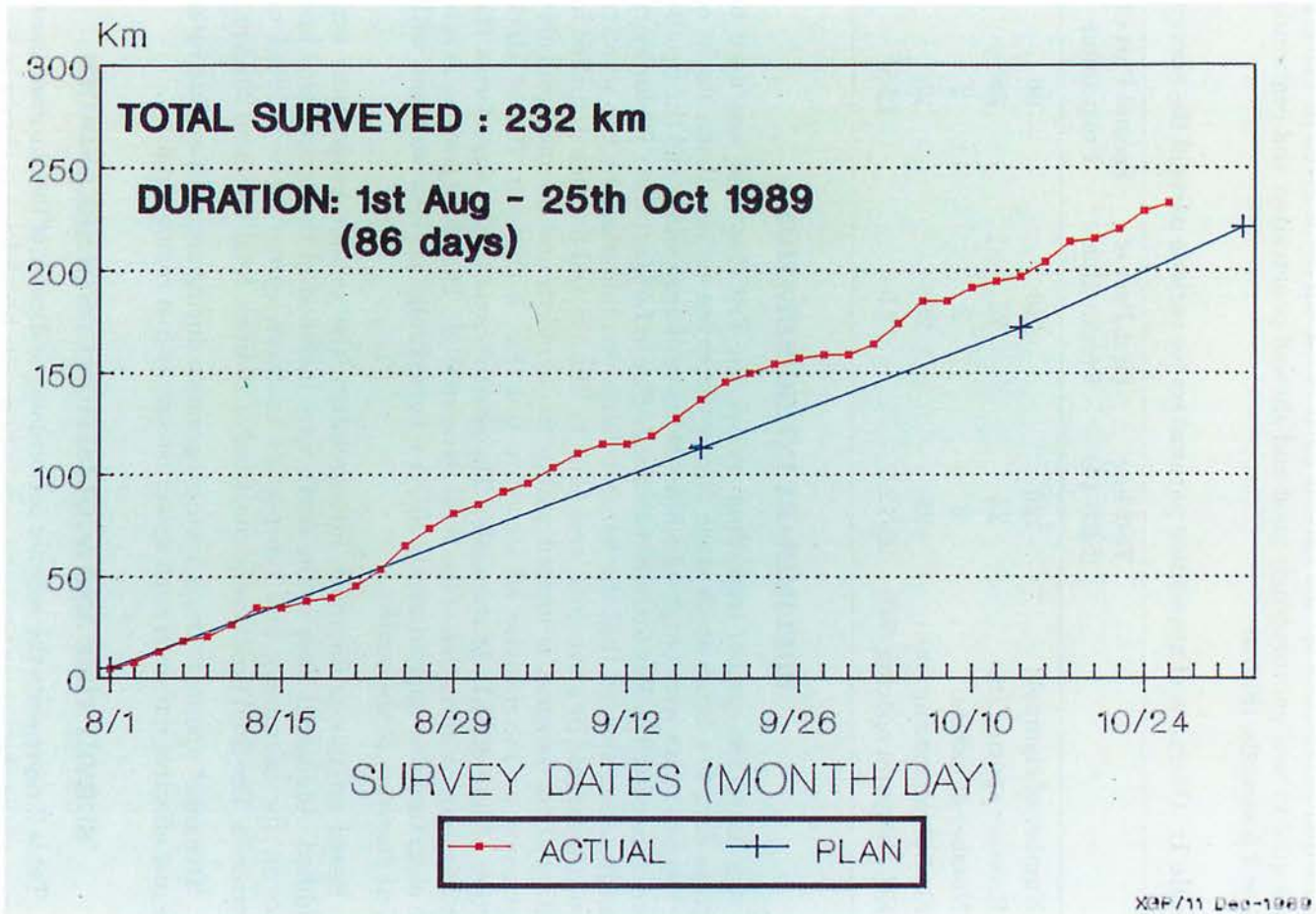

Figure 3: Production chart of the Saracen Bank survey (Digiseis)

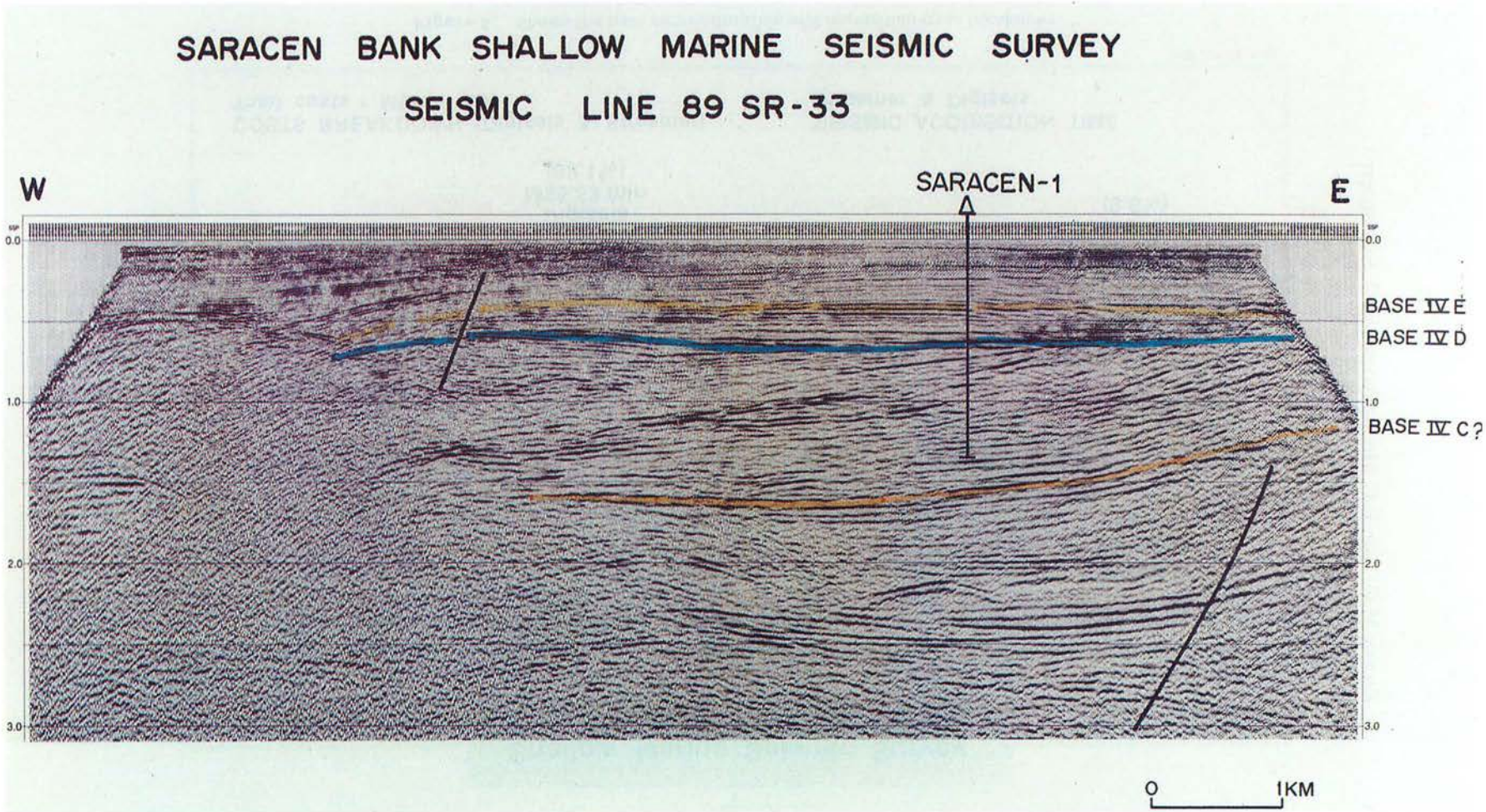

Figure 4 : Brute stack of Line 89SRB33 (Pass 1 + 2, 96 channels)

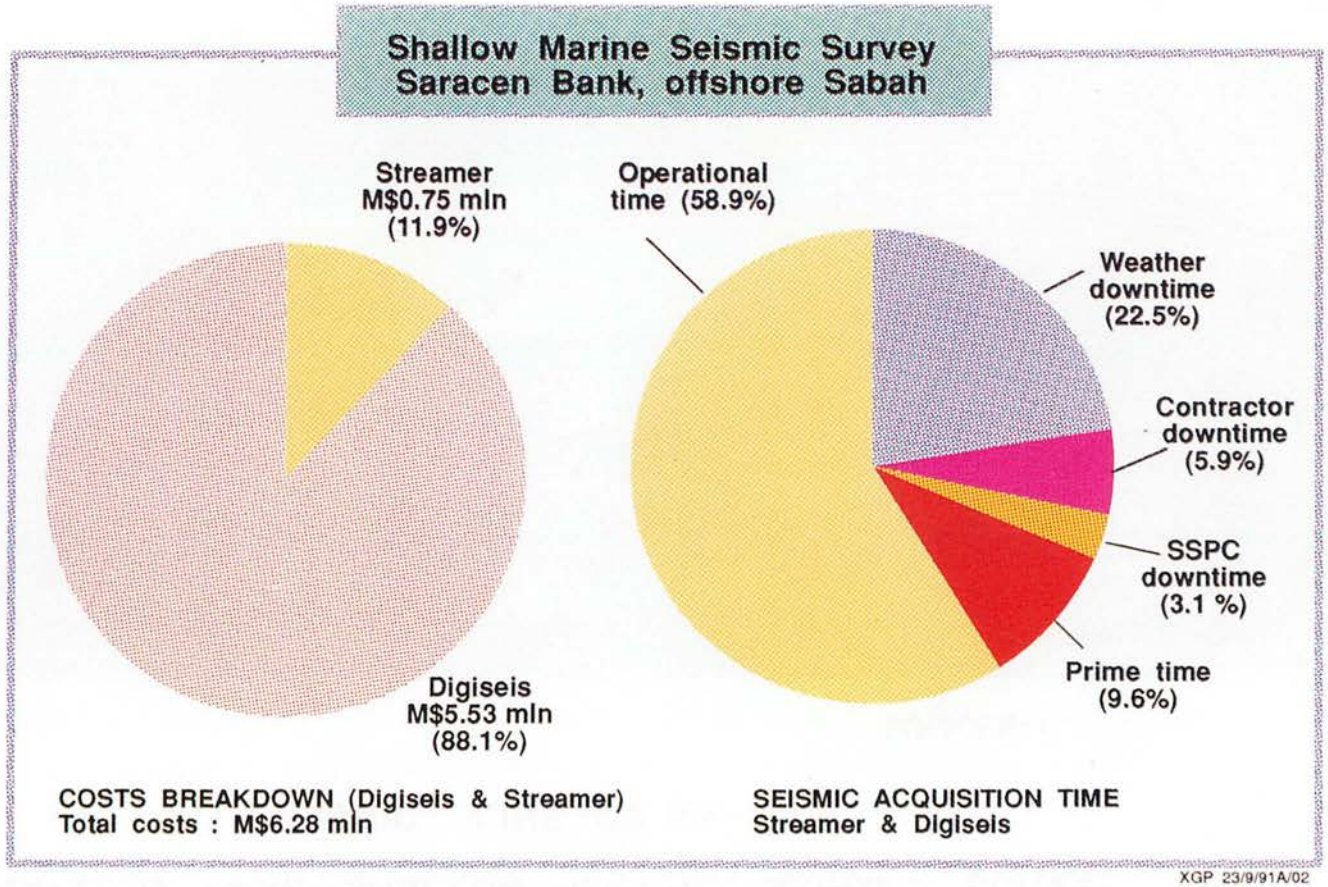

Figure 5: Shows the total survey duration and acquisition costs breakdown

Table 2: Seismic performance indicator of the Saracen Bank survey

	Planned km	Estimated km	Revised km	Final km
Digiseis	113	172	221	232
Streamer	154	141	173	197
Total	267	313	394	429

- Planned programme pre-start of the survey
- Estimated programme based on ongoing actuals
- Revised programme to include additional seismic
- Final programme

(Prime time reflects the actual shooting time, operational time includes all other activities including deploying, trouble shooting and retrieving the spread. Weather downtime includes electric storms and rain squalls. Seismic operations were less affected than expected by severe wave heights because of the protection provided by the reef.)

During the last part of the survey, operations were seriously affected by radio interference. On board processing results revealed that the effect of the interference on the data quality was not too damaging to the stack, and shows another important advantage of having an on board processing system for this type of special seismic operation.

EQUIPMENT QUALITY

Comprehensive Digiseis equipment tests were carried out before the start of survey by instrument specialists. The results indicated that some of the Data Acquisition Units did not initially meet the manufacturer's specifications. Test tapes were processed and analysed on the crew using the FACE system before the equipment was accepted. A rigorous quality control inspection was maintained throughout the survey as the daily test were processed and analysed onboard.

STREAMER PART OF THE SURVEY

After the completion of the Digiseis part of the survey, the streamer part was acquired using Contractor's shallow draft vessel "Western Orient" in water depths generally over 30 feet. Although operations were restricted to daylight only, the programme of 197km was acquired within 8 days. Typically, 2 km of overlap with the Digiseis part of the survey, as far as was operationally possible, was obtained to achieve an adequate tie-in with the two parts.

SAFETY AND ENVIRONMENTAL MATTERS

The targets of ZERO Lost Time Accident, ZERO Environmental Complaint and ZERO Fishmen's Compensation Claim were achieved by Sabah Shell and the Contractor. The Geophysical Department's Safety and Environmental Manual for Marine Seismic Operations provided the guideline for the safe operations whilst Contractor's Safety and Environmental programme, discussed and finalised prior to start of the survey, addressed matters specific to this shallow marine survey. The programme stipulates, among others, safety courses and equipment; operational procedures for small boat operations and petrol fuel dispensing; and environmental protection measures. Sabah Shell also conducted and documented a formal Environmental Impact Assessment on marine seismic surveys. Environmental impact was monitored closely throughout the survey and the impact was found to be neglibible.

CONCLUSION

Despite the relatively slow start to seismic production, the survey was a success, both in production and data quality. Dual modes of operation and onboard processing as a QC tool attributed to the cost effective acquisition technique for this specialised survey.

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