CSIR REPORT ENV-S-C 99057

BENGUELA CURRENT LARGE MARINE ECOSYSTEM
THEMATIC REPORT NO. 4

Integrated Overview of the Offshore Oil and Gas Industry in the Benguela Current Region

October 1999

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Integrated Overview of the Offshore Oil and Gas Industry in the Benguela Current Region

Submitted to:
THE UNITED NATIONS DEVELOPMENT PROGRAMME

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SCOPE

The Benguela Current Large Marine Ecosystem (BCLME) Thematic Report No. 4: Integrated Overview of the offshore Oil and Gas Industry in the Benguela Current Region was prepared as one of five reports serving as background for the Transboundary Diagnostic Analysis phase of the BCLME proposal.

The study covers:

- History of oil and gas exploration and production in the BCLME area,
- Geology of the areas with petroleum potential,
- Exploration methods (geophysical and drilling),
- Potential environmental impacts and mitigation measures,
- Oil spill response,
- Legislation,
- Issues and conflicts,
- Information gaps.

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CONTENTS

CHAPTER 1: INTRODUCTION

1.1 Objectives of the Study 1.1
1.2 Study Area 1.1

CHAPTER 2: HISTORY OF OIL AND GAS EXPLORATION AND PRODUCTION

CHAPTER 3: GEOLOGY

CHAPTER 4: SEISMIC SURVEY TECHNIQUES

4.1 Introduction 4.1
4.2 Environmental effects of seismic surveys 4.2

CHAPTER 5: EXPLORATION DRILLING

5.1 Introduction 5.3
5.2 Pre-drilling site surveys 5.4
5.3 The drilling operation 5.4
5.4 Well testing 5.6
5.5 Plugging and abandonment of exploration wells 5.6
5.6 The drilling mud 5.6
5.7 Cement 5.8

CHAPTER 6: ENVIRONMENTAL ASPECTS OF DRILLING

6.1 Introduction 6.1
6.2 Cuttings 6.1
6.3 Drilling mud 6.2
6.4 Other discharges into the sea 6.4
6.5 Solid waste 6.6
6.6 Atmospheric emissions 6.7

CHAPTER 7: OIL SPILLS AND CONTINGENCY PLANS

7.1 Contingency plans 7.1
7.2 Oil Spills 7.10

CHAPTER 8: LEGISLATION AND POLICY

8.1 Draft Decree on Environmental Protection for the Petroleum Industry .... page 8.2

CHAPTER 9: INTERNATIONAL CONVENTIONS AND ENVIRONMENTAL LAW

CHAPTER 10: ENVIRONMENTAL ISSUES ARISING FROM OFFSHORE OIL AND GAS EXPLORATION AND PRODUCTION

CHAPTER 11: INFORMATION GAPS

REFERENCES

CHAPTER 1:

INTRODUCTION

Contents

1. INTRODUCTION 1.1

1.1 Objectives of the Study 1.1

1.2 Study Area 1.1

1. INTRODUCTION

1.1 Objectives of the Study

This study aims to provide an overview of the offshore oil and gas industry in the Benguela Current region. The study covers the history of oil and gas exploration and production activities, the areas of interest, exploration methods, potential environmental impacts and mitigation measures, oil spill response and legislation. The study draws on existing, available information and identifies gaps in information and issues which could be addressed by the BCLME.

1.2 Study Area

The study area extends from the Cabinda Enclave north of the Congo River to the western half of the Agulhas Bank (longitude 21°E) on the south coast of South Africa (Figure 1.1).

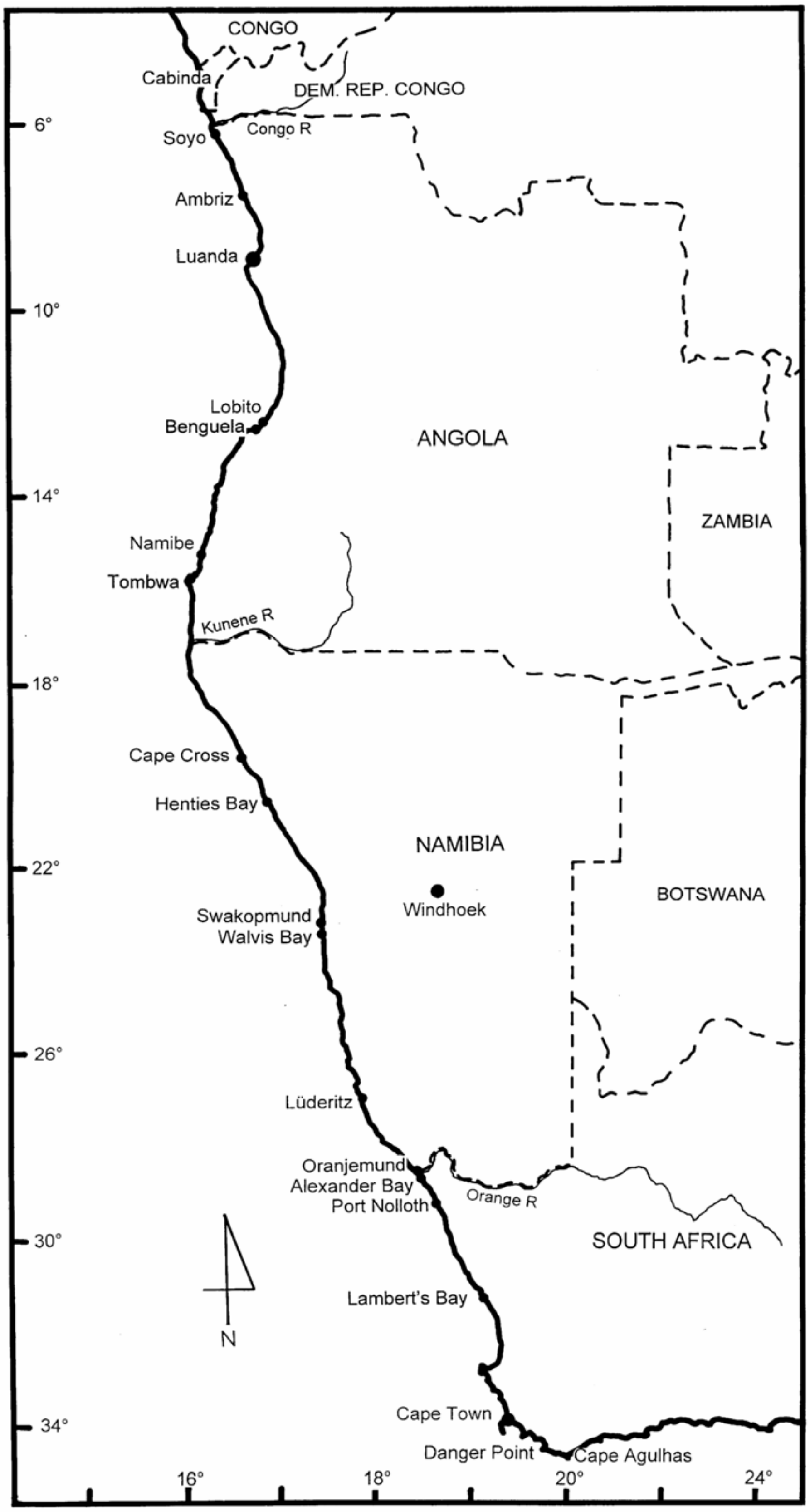


Figure 1.1: The BCLME study area: the southwestern coast of Africa between the Congo River mouth and Cape Agulhas

CHAPTER 2:

HISTORY OF OIL AND GAS EXPLORATION AND PRODUCTION

Contents

2. HISTORY OF OIL AND GAS EXPLORATION AND PRODUCTION . 2.1

Figures

Figure 2.1: Petroleum lease blocks on the Angolan continental shelf 2.3
Figure 2.2: Namibia: petroleum exploration licence blocks and location of exploration wells 2.5
Figure 2.3: Namibia: location of non-exclusive offshore seismic surveys 2.9
Figure 2.4: South Africa: Offshore licence blocks, participation blocks and mining leases 2.11
Figure 2.5: South Africa: licence areas in the BCLME study petroleum exploration area 2.13
Figure 2.6: South African offshore petroleum exploration: multi-channel seismic coverage 2.14
Figure 2.7: South Africa: Exploration wells drilled off the West-coast 2.15
Figure 2.8: Organisation of the South African Petroleum upstream sector 2.16
Figure 2.9: South Africa: aims and key members of the Agulhas Bank and West Coast Liaison Committee 2.18
Figure 2.10: Offshore Petroleum Association of South Africa: Objectives and Activities 2.19

Tables

Table 2.1: Petroleum exploration licences issued in Namibia since 1992 .... 2.6
Table 2.2: Namibia: post-1989 non-exclusive seismic surveys acquired for, or on behalf of, NAMCOR 2.7
Table 2.3: South African West Coast Petroleum Exploration Licences (As at June 1999) 2.17

HISTORY OF OIL AND GAS EXPLORATION AND PRODUCTION

ANGOLA

The following description of the history of oil exploration and production in Angola is taken from Africa south of the Sahara 1998 (27th Ed.) produced by Europa Publications, London.

In 1955 a Belgian-based company, Petrofina, discovered petroleum in the Cuanza valley. A petroleum company, Fina Petróleos de Angola (PETRANGOL), was subsequently established, under the joint ownership of the Angola government and Petrofina interests. PETRANGOL constructed a refinery in the suburbs of Luanda. The greatest impetus to expansion came from the Cabinda Gulf Oil Co (Cabgoc), which discovered petroleum offshore at Cabinda in 1966. In 1976 a national oil company, the Sociedade Nacional de Combustíveis de Angola (SONANGOL), was established to manage all fuel production and distribution. In 1978 SONANGOL was authorized to acquire a 51% interest in all petroleum companies operating in Angola, although the management of operations was to remain under the control of foreign companies. In the late 1970s the government initiated a campaign to attract foreign oil companies. In 1978-79 SONANGOL divided the Angolan coast, excluding Cabinda, into 13 exploration blocks, which were leased to foreign companies under production-sharing agreements. Although Cabgoc's Cabinda offshore fields (which are operated by the US Chevron Corpn) remain the core of the Angolan petroleum industry (accounting for about two-thirds of total output), production is buoyant at other concessions, held by Agip, Elf Aquitaine, Conoco and Texaco. In addition SONANGOL itself operates a production block in associated with Petrobrás Internacional (BRASPETRO) of Brazil and Petrofina. In 1992 Elf took a 10% interest in Cabgoc, reducing SONANGOL's share to 41%, with Chevron holding 39.2% and Agip 9.8%. Onshore, Petrofina remained the operator. SONANGOL took a 51% interest in Petrofina's original Cuanza valley operations, including the Luanda refinery, whose capacity meets most domestic requirements. SONANGOL also had a 51% interest in an onshore venture by Petrofina in the River Congo estuary area, in which Texaco held a 16.33% share. Onshore production in 1991 was estimated at 30,000 b/d; however, with recoverable petroleum reserves almost exhausted and activities vulnerable to UNITA attack, production declined and in 1993 Petrofina suspended onshore operations near the port of Soyo, in northern Angola near the Zaire border. Production was resumed, however, in February 1996, and an output of 5,000 b/d was quickly restored. It was forecast that production would advance to 12,000 b/d by early 1997.

Despite the uncertain security situation in the Cabinda enclave, exploration licences for three onshore blocks were awarded in October 1992. The principal operators for the three concessions, Cabinda North, Central and South, were to be Occidental of the USA, British Petroleum and Petrofina respectively. In 1994 Chevron announced the discovery of four new offshore fields. It estimated that production would increase from 320,000 b/d in 1994 to 390,000 b/d in 1995 as the development of deep-water areas continued under its five-year programme. In 1995 Chevron announced a US $5,100 m capital and exploration expenditure programme for that year, an increase of 5% on 1994. In 1997 Chevron announced its intention to invest $700 m a year until 2000 and envisaged increasing its output to 600,000 b/d. In late 1994 Texaco announced a five-year investment programme for petroleum exploration and production totalling $600 m; the programme aimed to increase Texaco's output in the country by 50%. In September 1996 SONANGOL signed new production sharing agreements with six international petroleum companies: Shell Exploration Angola, Amoco Angola, Eagle (Nigeria), Petro Inett Corpn (South Africa), Mobil and Texaco.

Output of petroleum expanded rapidly during the 1980s, reflecting continued investment in the sector. it was estimated that total investment in Angola by oil companies for the period 1987-90 would reach US $2,050 m. Total Angolan production averaged 155,00 b/d in late 1982, rising to about 285,000 b/d in 1986, to 358,000 b/d in 1987 and to 450,000 b/d in 1988 and 1989. Output rose to 475,000 b/d in 1990, 490,000 b/d in 1991, and 549,000 b/d in 1992. Following a small decline in 1993, production increased consistently, reaching an estimated 750,000 b/d in 1997. Output was projected to increase to 780,000 b/d by 1998, of which 450,000 b/d would be produced by Chevron in Cabinda's offshore fields alone, and to 1 m b/d by 2000. In April 1997 Chevron announced the discovery of a further new oil field of the coast of Cabinda which was thought capable of producing an additional 20,000 b/d. In May, following another significant deep-water discovery, production began in the remote North N'Dola oil field, which was expected to yield up to 20,000 b/d by the end of 1997. In August Elf Aquitane announced the discovery of one of Africa's largest ever petroleum field, with estimated reserves of 3,500 m barrels, off the Angolan coast. In that year the law governing the exploitation of petroleum was under revision with a view to facilitating further foreign investment. Petroleum production appeared to be relatively unaffected by the resumption of hostilities in late 1992, and the main installations in Cabinda escaped attack by UNITA or the regional separatist organization, FLEC. Before withdrawing from Soyo in late 1994 UNITA destroyed the onshore installations. However, in March 1995 the government announced that production would resume, although at a reduced rate of 5,000 b/d.

The major portion of Angola's petroleum is exported to the USA in its crude form (397,000 b/d during 1997), although the 30-year-old Luanda refinery processes around six tons of crude petroleum per day. The government announced in April 1998 that it intended to invest US $10 m to upgrade and increase the capacity of the Luanda refinery. There are also plans to construct a new refinery, with financial support from the People's Republic of China, at Lobito. The new refinery, which was expected to be completed by 2003, was to cost some $1,000 m and would be capable of processing 200,000 b/d.

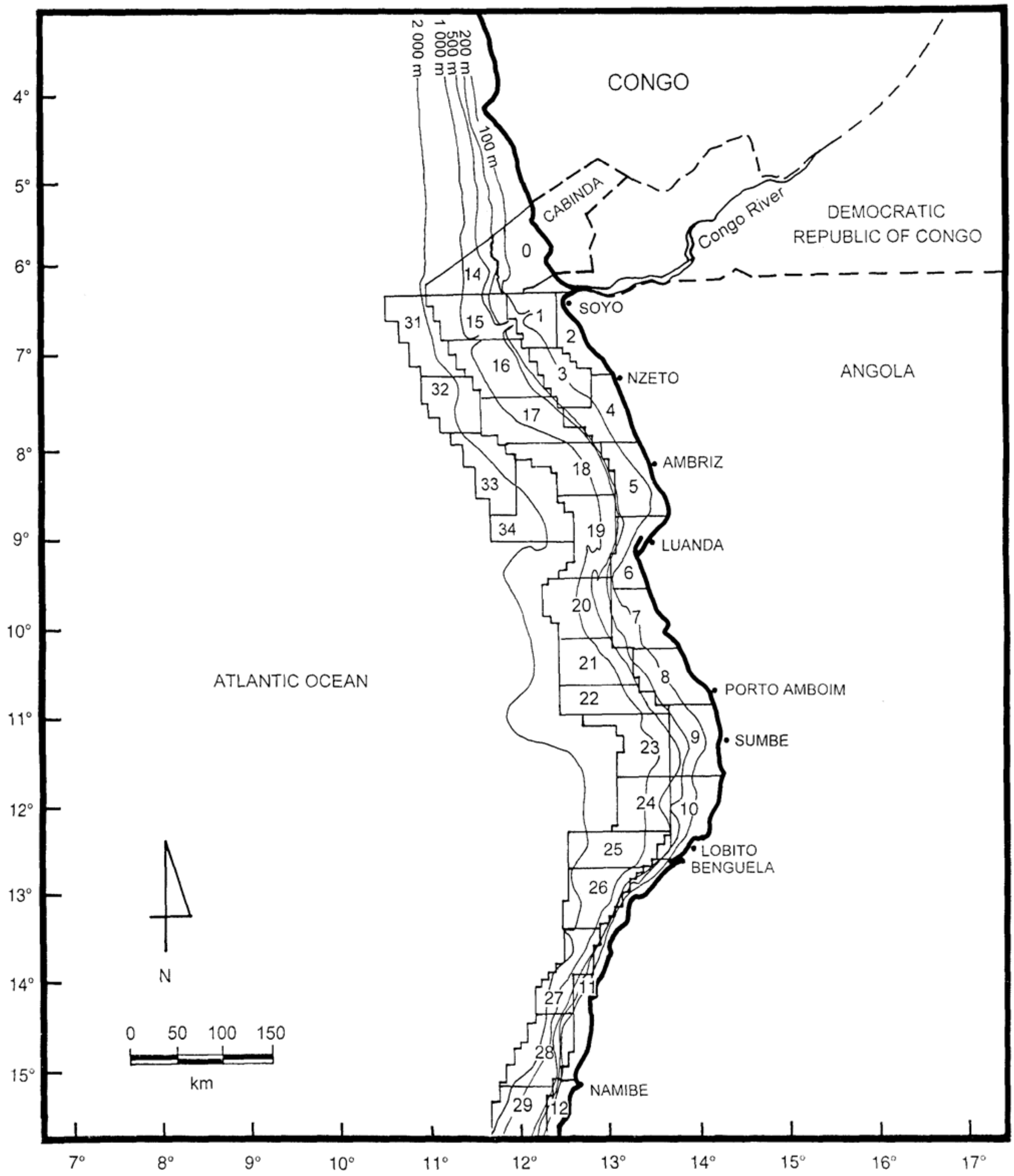


Figure 2.1: Petroleum lease blocks on the Angolan continental shelf

Angola's export earnings from petroleum increased after 1982, following the rise in production, and reached US $1,191 m in 1985. With the sharp fall in the price of petroleum, export earnings declined to $1,140 m in the following year, but recovered to $2,100 m in 1987, $2,250 m in 1988, $2,700 m in 1989 and - helped by increased production and a period of higher prices, due to the Gulf crisis - an estimated $3,250 m in 1990. In 1991 petroleum export earnings stood at $3,217 m, increasing to $3,556 m in 1992 before declining to $2,813 m in 1993. In 1995 estimated earnings from petroleum exports stood at $5,000 m. As Angola is not a member of OPEC, the country is not constrained by production quotas, enabling it to stabilize the value of its petroleum exports during the late 1980s, when world prices remained depressed, by increasing output.

The entire Angolan continental shelf has been divided into Lease Blocks (Figure 2.1). At present interest has been focussed on the northern continental shelf although exploration (geophysical surveys) is now taking place as far south as Lobito (Lease Block 25).

NAMIBIA

In the 1960s, South Africa, which was administering the then South West Africa, made a concerted effort to encourage petroleum exploration. This was administered by SWAKOR, the predecessor of the National Petroleum Corporation of Namibia (NAMCOR), and SOEKOR, the South African equivalent of SWAKOR. Seismic surveying offshore Namibia began in 1968. By 1974 the whole offshore was covered by licences. Although concentrated on the continental shelf down to 200 m, some seismic surveys extended as far as 250 km offshore along the Walvis Ridge and down to water depths of 1 500 m. A total of 37 219 km of 2-D seismic data was acquired up to 1978 but only one well was drilled. This was the Kudu 9A-l well drilled by Chevron, Regent and SOEKOR in 1974 which discovered the Kudu gas field some 170 km due west of Oranjemund in water 170 m deep.

During this same period, the deep-sea drilling programme (DSDP) drilled four wells in deep water on or near the Walvis Ridge. These were important for understanding the Namibian offshore geology and its petroleum potential.

With the intention of investigating the Kudu gas discovery further, SWAKOR acquired 239 km of 2D seismic data in 1985 around the Kudu 9A-1 well. It then drilled the Kudu 9A-2 well in 1987 and the Kudu 9A-3 well in 1988. Kudu 9A-2 encountered gas in the main reservoir sandstone but on the advice of consultants this was not tested. The highly successful Kudu 9A-3 well, which flowed at a rate of 38 million cubic feet of gas per day, proved that the size of the Kudu gas reservoir is significant.

A potential reserve of at least 5 trillion cubic feet (TCF) of gas was estimated. This is still the largest reserve of natural gas south of Angola. It also proved that the reservoir sandstone covers a large area, that source rocks are present, that the volumes of gas present are large enough to be of commercial interest and that the southwestern offshore region of Africa could well be a petroleum province (Miller, 1998b).

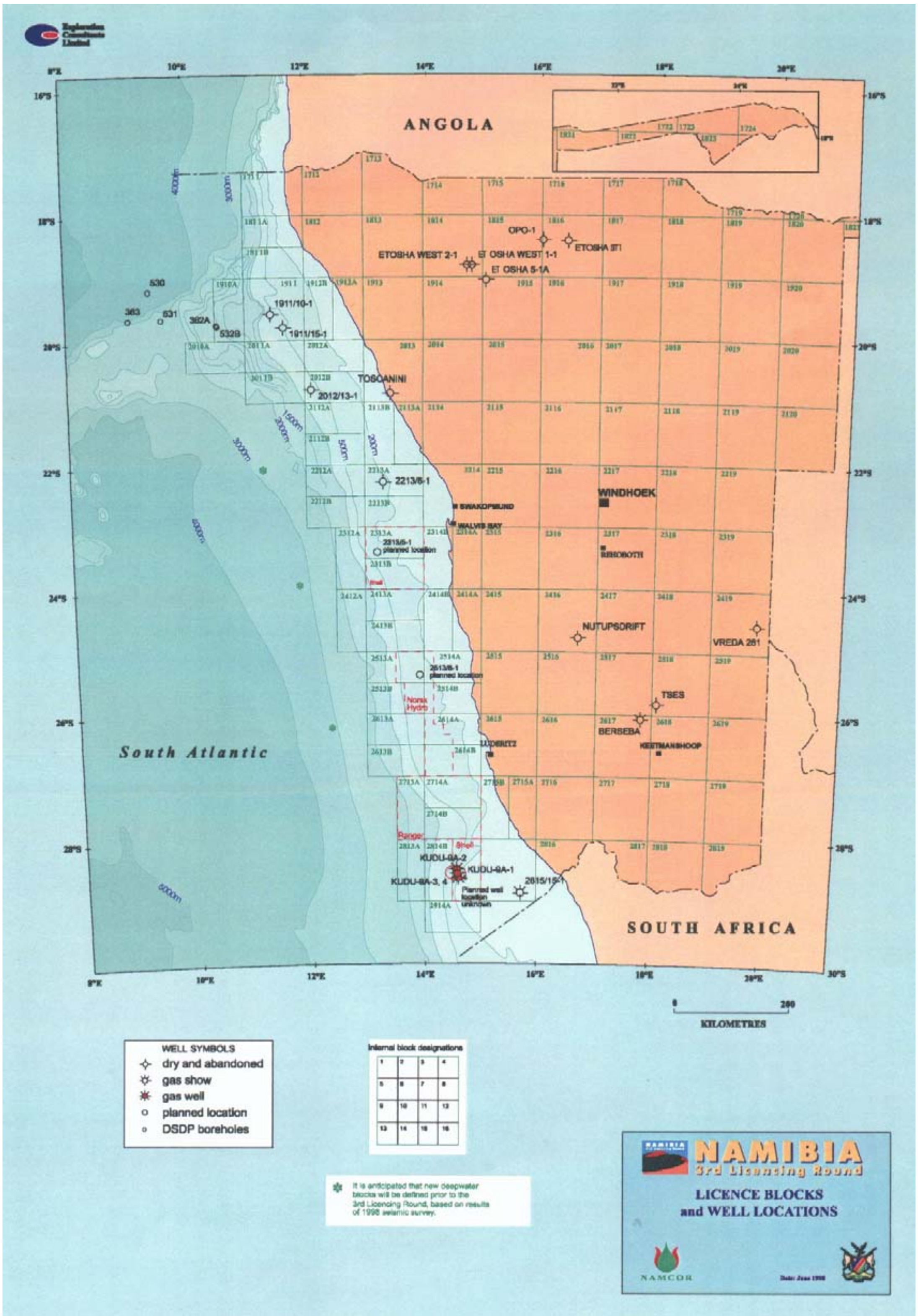


Figure 2.2: Namibia: petroleum exploration licence blocks and location of exploration wells

Compilation of up-to-date, progressive, straightforward yet comprehensive and strict petroleum legislation began just prior to Namibia's independence with assistance from consultants, the Government of the Kingdom of Norway and the Commonwealth Secretariat.

Namibia's first petroleum licensing round opened in 1991 and attracted 19 bids for 14 licence areas each covering approximately 11 000 km^2. Up to six bids were received for specific areas. The first exploration licence was awarded by the Government of the Republic of Namibia in April 1992 to a consortium of Norwegian companies headed by Norsk Hydro Namibia. Shell Exploration and Production Namibia (SEPN) and its partner Eagle Energy (now Energy Africa) were awarded a licence over the Kudu gas field. Texaco joined that consortium in 1996. The second licensing round was held in 1994/95. The third opened on 1 October 1998 and will close on 31 March 1999. Third round licences are expected to be awarded during the year 2000. Table 2.1 lists the licences issued during the first and second licensing rounds, the renegotiated licences, the partners in each licence, the seismic data acquired and the wells drilled. Figure 2.2 shows the location of the wells.

All licences awarded so far have been for offshore areas within the Namibian Exclusive Economic Zone. Since the award of the first licence, over 28 000 km of new 2-D seismic data and 700 km of 3-D seismic data (the first in Namibia) have been acquired, processed and interpreted by exploration companies and the data lodged with NAMCOR. In addition, eight widely spaced wells, some up to 4 500 m deep, have been drilled between 40 and 120 km offshore in water depths ranging from 170 m to almost 700 m.

Table 2.1: Petroleum exploration licences issued in Namibia since 1992

LICENCE NO	LICENCE AREA	OPERATOR	PARTNERS	TOTAL SEISMIC ACQUIRED (km)	TOTAL WELLS DRILLED; TOTAL DEPTH (m)	AEROMAG-NETIC SURVEYS (km)	STATUS OF LICENCE
First Round Licences							
001	1911	Norsk Hydro Namibia	Statoil, Saga Petroleum	2D B 8010	1911/15-1 B 4564m 1911/10-1 - 4185m	32 500	Relinquished
002	2213N	Ranger Oil Namibia	Hardy Oil & Gas, Amarada Hess	2D - 2300	2213/6-1 B 2605m		Relinquished
003	2012	Sasol Petroleum		2D - 5889	2012/13-1 B 3699m	28 340	Relinquished
004	2815	Chevron Overseas Namibia	Energy Africa, Shell Namibia	2D - 3244	2815/15-1 B 4750m		Relinquished

LICENCE NO	LICENCE AREA	OPERATOR	PARTNERS	TOTAL SEISMIC ACQUIRED (km)	TOTAL WELLS DRILLED; TOTAL DEPTH (m)	AEROMAG-NETIC SURVEYS (km)	STATUS OF LICENCE
			Exploration				
005	2814A (Blocks 3,4,7,8, 11,12)	Shell Exploration and Production Namibia	Energy Africa, Texaco	2D B 2095 3D B 700km^2	Kudu 4 - 4705 m Kudu 5 B 4898 m		Whole enlarged licence area declared a petroleum field
Renegotiated First Round Licences							
006	2713A, 2714	Ranger Oil Namibia	Hardy Oil & Gas, Amarada Hess	2D - 3000			Relinquished
008	Parts of 2513, 2514, 2614	Norsk Hydro Namibia	Statoil, Saga Petroleum	2D - 1400	2513/6-1 - < 3000m		To be relinquished end 1998
Second Round Licences							
007	2313	Shell Namibia Exploration		2D B 2500			Still current
005		Blocks 15 and 16 of area 2814 added to Licence 005					

Since 1989, NAMCOR, through various agents, has acquired 19 500 km of 2-D non-exclusive seismic data which has been used to promote the potential of the Namibian offshore and to attract investment. Figure 2.3 shows the location of the various non-exclusive seismic surveys listed in Table 2.2.

Table 2.2: Namibia: post-1989 non-exclusive seismic surveys acquired for, or on behalf of, NAMCOR

SURVEY	YEAR	TOTAL LENGTH OF SURVEY LINES (km)
HGS/ECL 1989 Regional seismic survey, Namibia (marketed by GeoQuest)	1989	10 002
HGS/ECL 1991 Regional seismic survey, Namibia (Namibe and Walvis Basins) (marketed by GeoQuest)	1991	3 774
NAMCOR 1992 seismic survey, Walvis Basin (marketed by NOPEC)	1992	1 165
NOPEC 1993 seismic survey, Namibe and Walvis Basins	1993	10 077
NAMCOR 1995 seismic survey, Lüderitz Basin (marketed by GeoQuest)	1995	1 950
Western Geophysical 1997 seismic survey, Namibe Basin	1997	1 217
NAMCOR/GECO 1997 Orange Basin seismic survey, (west and south	1997	1 036

SURVEY	YEAR	TOTAL LENGTH OF SURVEY LINES (km)
Kudu)(marketed by GeoQuest)		
Western Geophysical 1998 deep-water survey, Walvis and Lüderitz Basins	1998	5 117

Investment in petroleum exploration in Namibia since 1989

The total investment by exploration licence holders on environmental impact assessments, training of Namibians, contributions to the Petroleum Education and Training Fund, seismic acquisition and drilling of wells has been approximately N$ 580 million since independence. The Government and NAMCOR, together with NORAD and private seismic companies have also spent considerable amounts on internationally promoting petroleum exploration in Namibia, on the administration of exploration activities and on training Namibians to understand and administer the upstream petroleum industry. The largest contributor since 1990 in this regard outside the private sector has been NORAD which provided N$ 37 million. In the same period, Government contributed N$ 6.8 million and NAMCOR spent N$ 11.2 million of its own funds. Seismic acquisition companies, recognising the potential for significant sales of seismic data, spent the equivalent of N$ 88 million of their own money in acquiring non-exclusive seismic data under contract to NAMCOR.

Areas of interest

Figure 2.2 shows the licence areas on offer in Namibia's 3rd Licencing Round. Although these areas extend to the onshore, the known offshore geology strongly suggests that petroleum exploration south of the Walvis Ridge, where the continental shelf is approximately 100 km wide, is only likely to take place beyond about 40 km from shore and that most of this exploration will be in water depths of between 150 m and 1 500 m, i.e. between about 70 and 180 km offshore. This assumption is based on the fact the parts of the Namibian stratigraphic succession in the deeper offshore has many similarities to the West African deep-water geological succession where several huge discoveries have been made in the past few years in water depths of up to 1 400 m. The Kudu gas field occurs in water depths of 170 m. The 1998 seismic survey acquired by Western Geophysical recorded to water depths of 3 500 m to allow proper coverage and therefore proper interpretation and evaluation of geological structures at slightly shallower water depths (Shell has been drilling exploration wells in water depths of 2 400 m in the Gulf of Mexico).

In the Namibe Basin exploration may well take place closer to shore since the continental shelf here is only about 35 km wide and geology below the shelf and the continental rise as it extends into deeper water has many interesting structures. The 2 000 m isobath is approximately 70 km offshore.

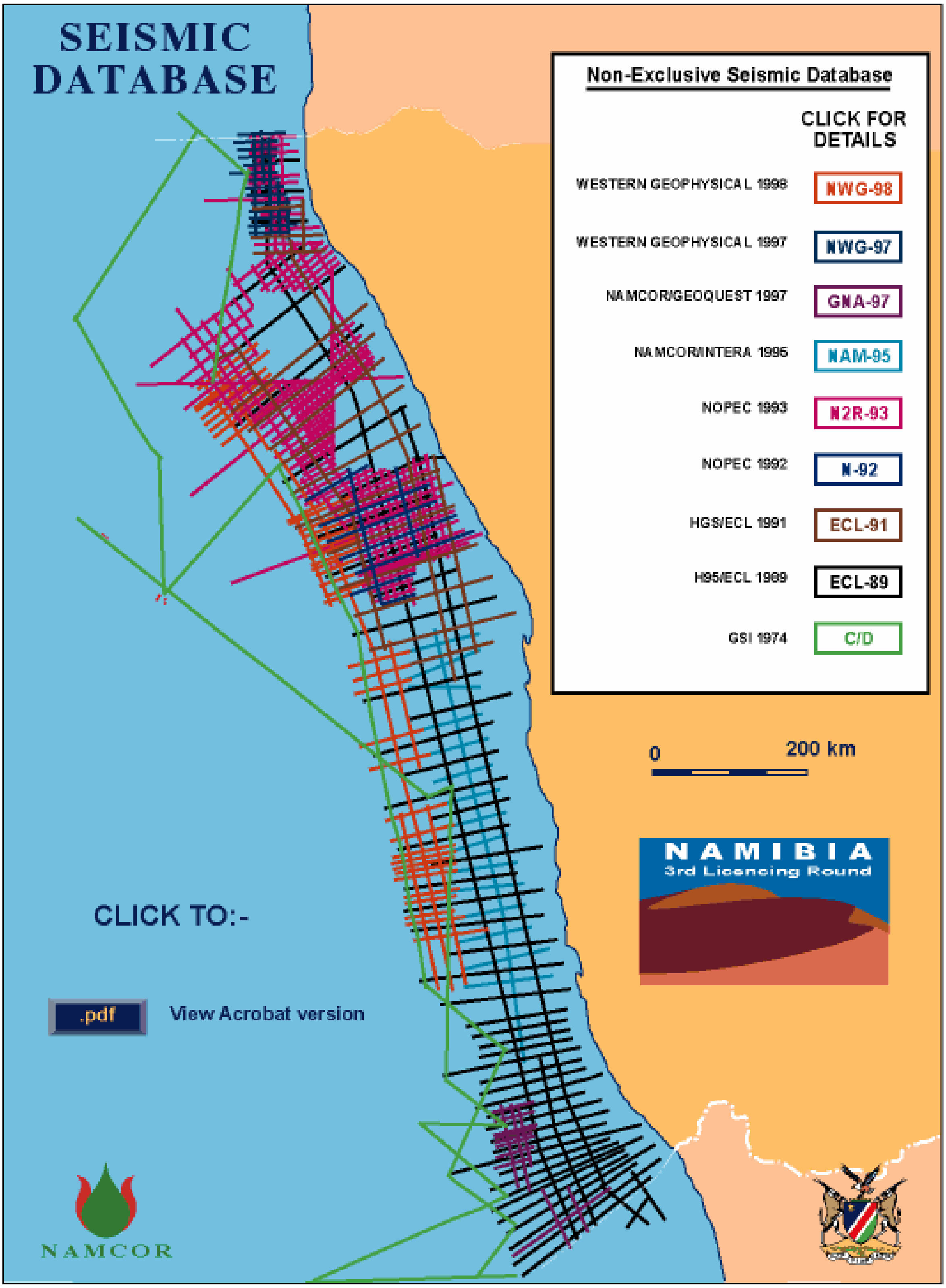


Figure 2.3: Namibia: location of non-exclusive offshore seismic surveys

SOUTH AFRICA

The following description of the history of oil and gas exploration in South African waters has been compiled from Graham *et al.* (1997) and Van Vuuren *et al.* (1998) and information provided by the SOEKOR Petroleum Licencing Unit.

In 1951 Dr Franz Quass, a senior research officer of the Fuel Research Institute of South Africa, published a report that contained two critical recommendations: that the then Union of South Africa commence an organised oil search as soon as possible and that sufficient synthetic fuel plants be established to make the country independent of imported oil supplies within 20 to 25 years (Quass, 1951). Almost 15 years were to pass before the changing domestic and world scenario eventually gave new impetus to the idea of South Africa's own oil search - and the formation of SOEKOR.

The Southern Oil Exploration Corporation (Pty) Ltd was registered on 12 January 1965. From the outset it was known as "SOEKOR", but it was only in 1980 that this became its official name. SOEKOR was charged with the responsibility of not only exploring for oil alone, but also of co-ordinating the efforts of other companies and of actively encouraging exploration onshore and offshore.

SOEKOR was granted oil and gas exploration rights to all South African areas which had not already been leased. These included various onshore areas under a number of different leases, the last of which was Prospecting Lease OP 29 (which terminated in 1992) and most of the continental shelf under Prospecting Lease OP 26. Originally OP 26 extended only to the 200 m water depth contour. In line with international practice, it was subsequently extended to also cover the exclusive economic zone which extends out to sea for 200 nautical miles from the shoreline.

Offshore, the international companies started off vigorously, competing for the 50% tax reduction promised to the first discoverers of commercial oil and gas offshore. Aeromagnetic and seismic surveys were carried out, and in 1969, Superior drilled the first well which discovered non-commercial quantities of gas, with some condensate, off Plettenberg Bay. Other companies joined in the race: Placid Oil Company, Chevron, Elf Aquitaine, the Total Consortium (in which Mobil and Shell had interests), the Odeco Consortium (in which Sasol had an interest), and a Rand Mines consortium (in which SOEKOR had an interest). The next gas strike was made by a Chevron/Regent/SOEKOR group in 1974, when they discovered the Kudu gas field offshore Namibia. Among further discoveries made by SOEKOR in South African waters were the F-A gas field, discovered in 1980 and the E-BT (ORIBI) oil field, discovered in 1990. The South Coast, particularly the Bredasdorp Basin (Block 9), received the main focus of interest in following years when wells were drilled to follow up on the early gas discoveries and the possibility of additional and hopefully larger oil fields.

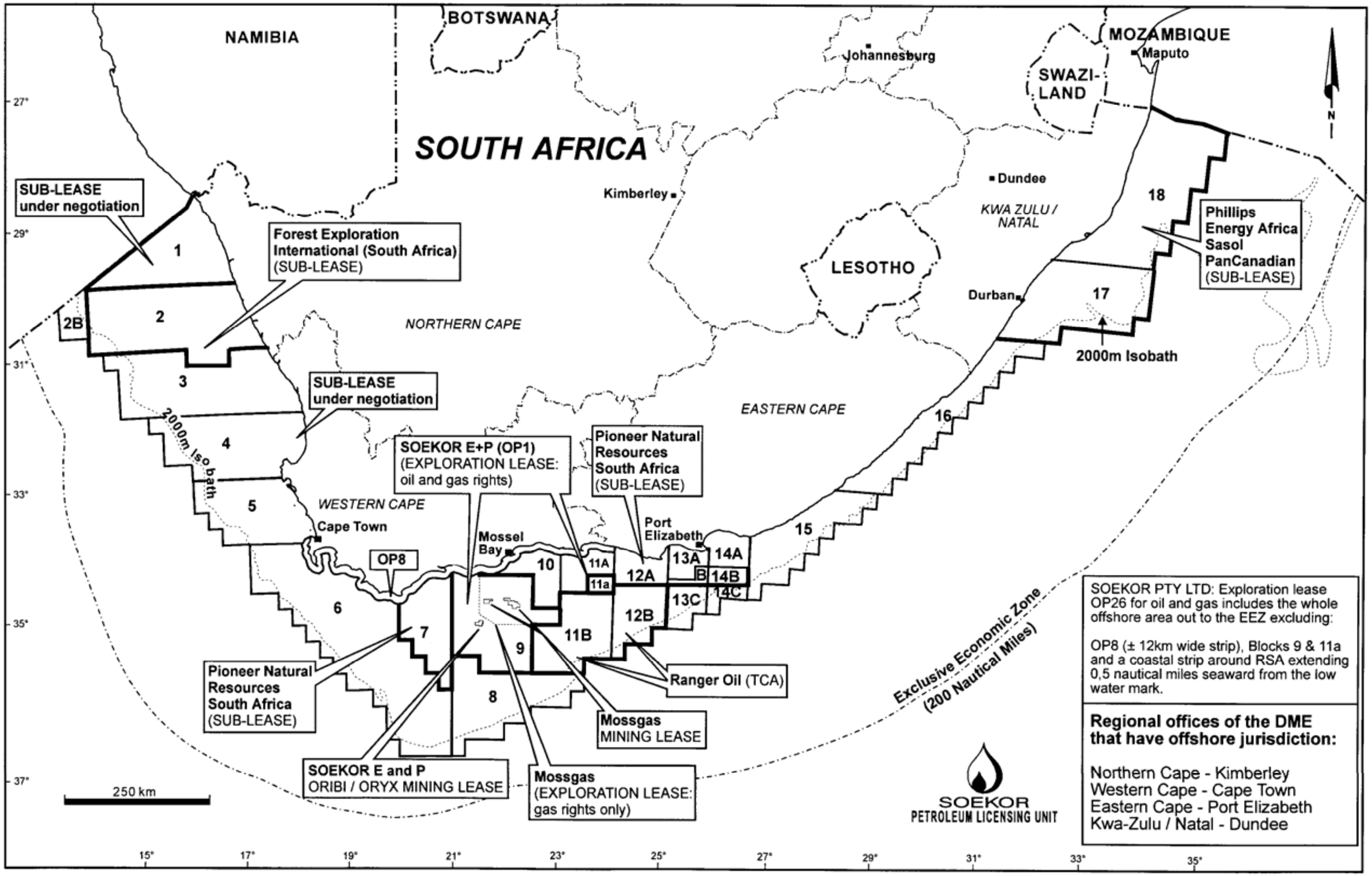


Figure 2.4: ***South Africa: Offshore licence blocks, participation blocks and mining leases***

A total of 194 exploration, 58 appraisal and nine production wells have been drilled off the South African coast and 190 000 km of two-dimensional and 2 300 km^2 of three-dimensional seismic data have been acquired. Exploration has resulted in 20 gas and nine oil discoveries, all but two of which are located in the Bredasdorp basin. The F-A gas field is presently in production and the E-BT (ORIBI) oil field commenced production in 1998.

Some 30 wells have been drilled off the west coast of South Africa, i.e. in the BCLME study area (Figure 2.5 and Figure 2.7).

Despite the early promise of the Kudu gas discovery, the pace of exploration on the West Coast has been relatively slow. Of the companies that took up licences (Chevron, Elf Aquitaine, Esso and Amoco), only Elf Aquitaine proceeded with drilling three wells. By the end of 1976, all foreign exploration companies had left the area and SOEKOR carried on as sole explorer. By 1992, 48 000 km of 2D seismic data had been acquired and 30 wells drilled on the South African West Coast, resulting in one oil and three gas discoveries. More than half of the wells had gas shows.

In 1987, Energy Africa (formerly Engen), joined SOEKOR as a partner in the exploration for oil in the Bredasdorp Basin (Block 9). This arrangement lasted until 1995 and during this time, a number of potentially commercial oil and gas discoveries were made.

Another major development in 1987, was the decision by the government to proceed with the development of the FA gas field. Mossgas was established as a separate company to manage the project, under the Central Energy Fund and was awarded mining leases over the FA and EM gas fields. The decision was taken to use a bottom supported platform to produce gas and condensate and to export both products to a shore-based factory where the gas would be converted by a modified Fishcher Tropsch process (the Synthol process) into petrol and diesel. Production started in 1992 and has been continued at a rate of about 183 million standard cubic feet of gas and 10 500 barrels of condensate per day.

By 1993, the winds of political change were blowing strongly as oil sanctions fell away and the government of the day looked to withdraw from direct participation in the petroleum search. The pace of exploration and associated funding was dramatically reduced and SOEKOR put in place a process of restructuring and right-sizing.

A public licensing round was held in October 1994 (just 5 months after the national elections) to attract international exploration companies. Despite selling a significant amount of data, no applications were received. An independent consultant was appointed to establish the reasons for the negative response. High on the list were uncompetitive tax rates and uncertainty about how the new government would manage the economy, particularly the petroleum sector.

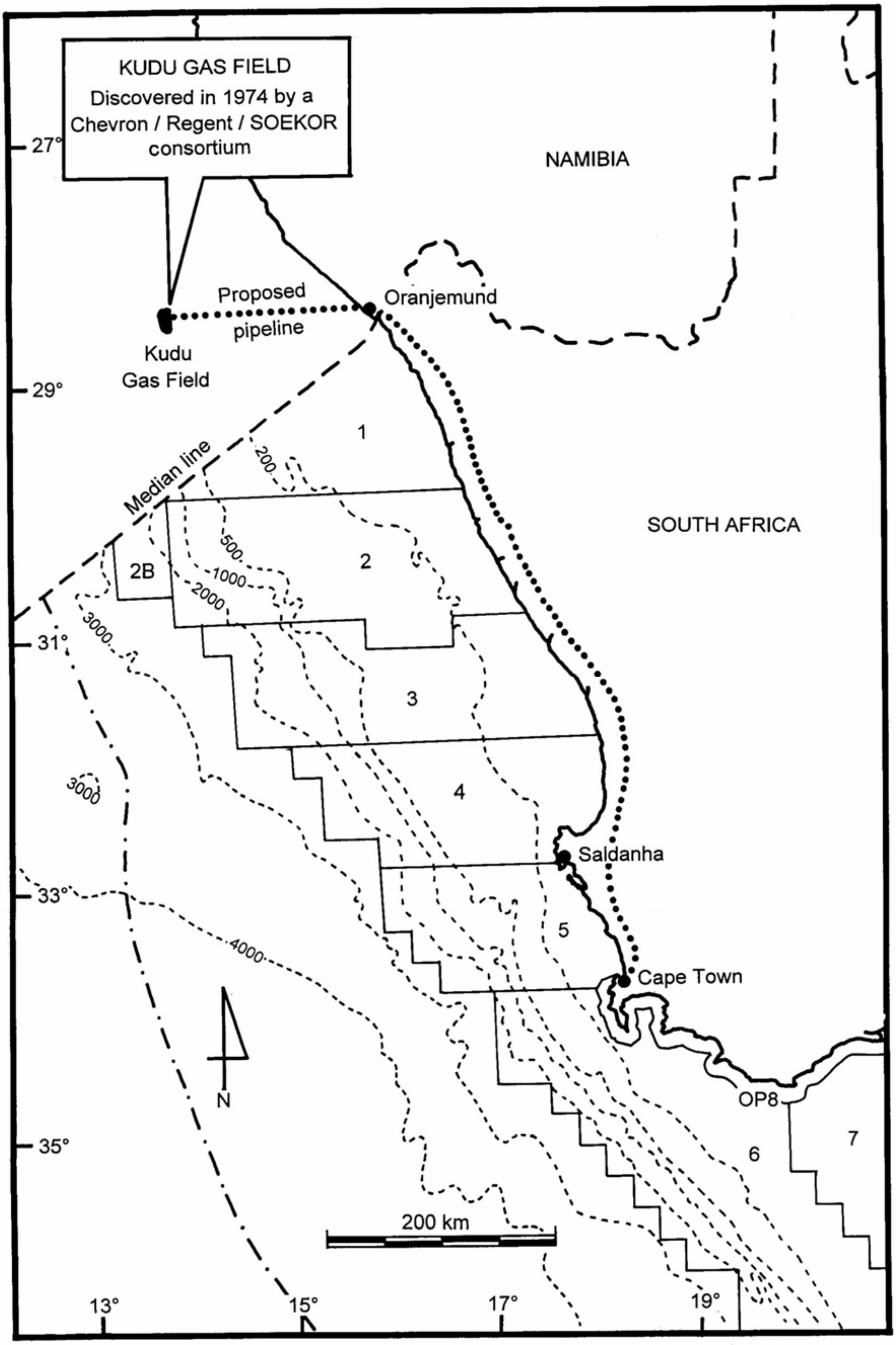


Figure 2.5: South Africa: licence areas in the BCLME study petroleum exploration area

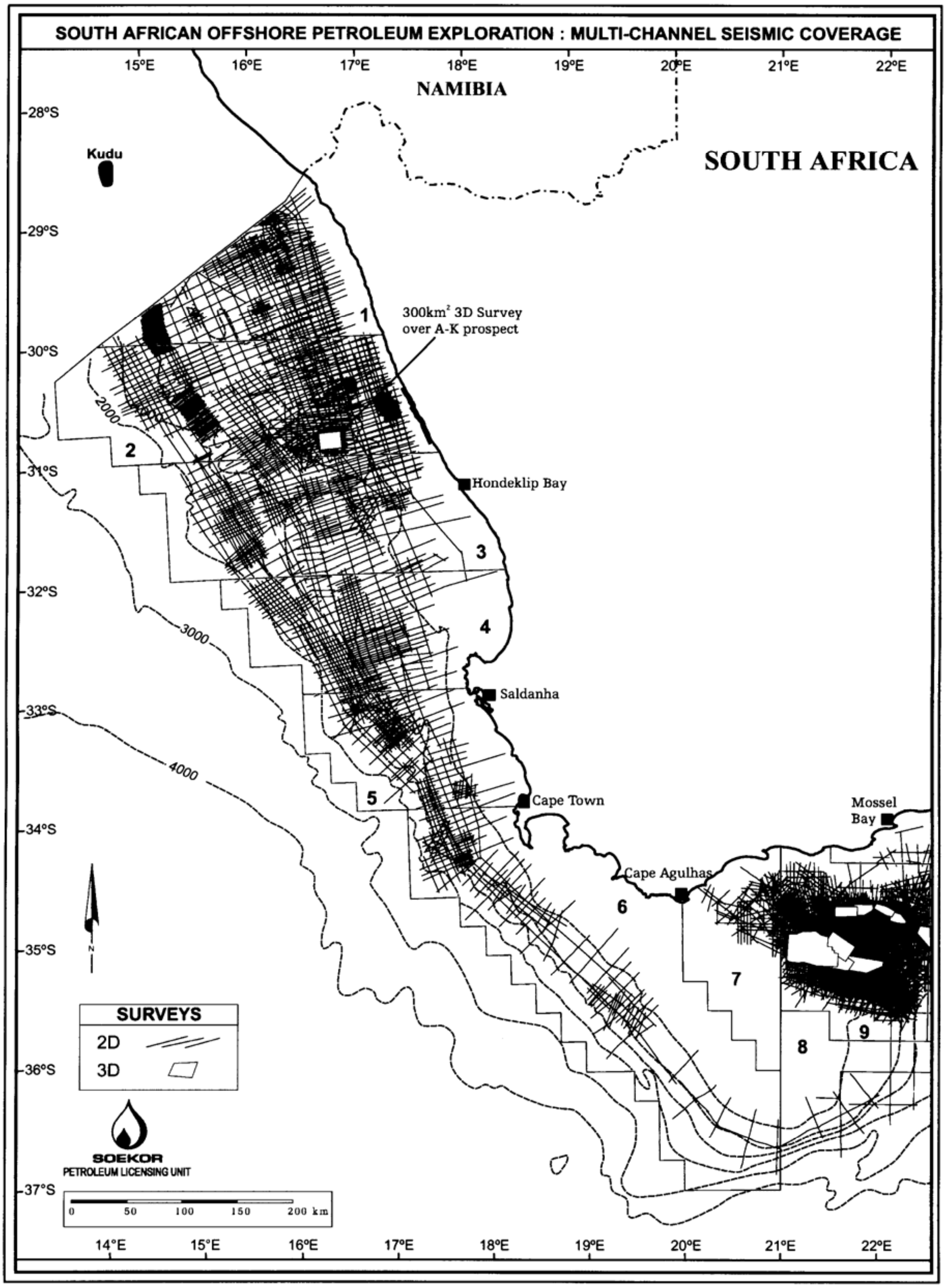


Figure 2.6: ***South African offshore petroleum exploration: multi-channel seismic coverage***

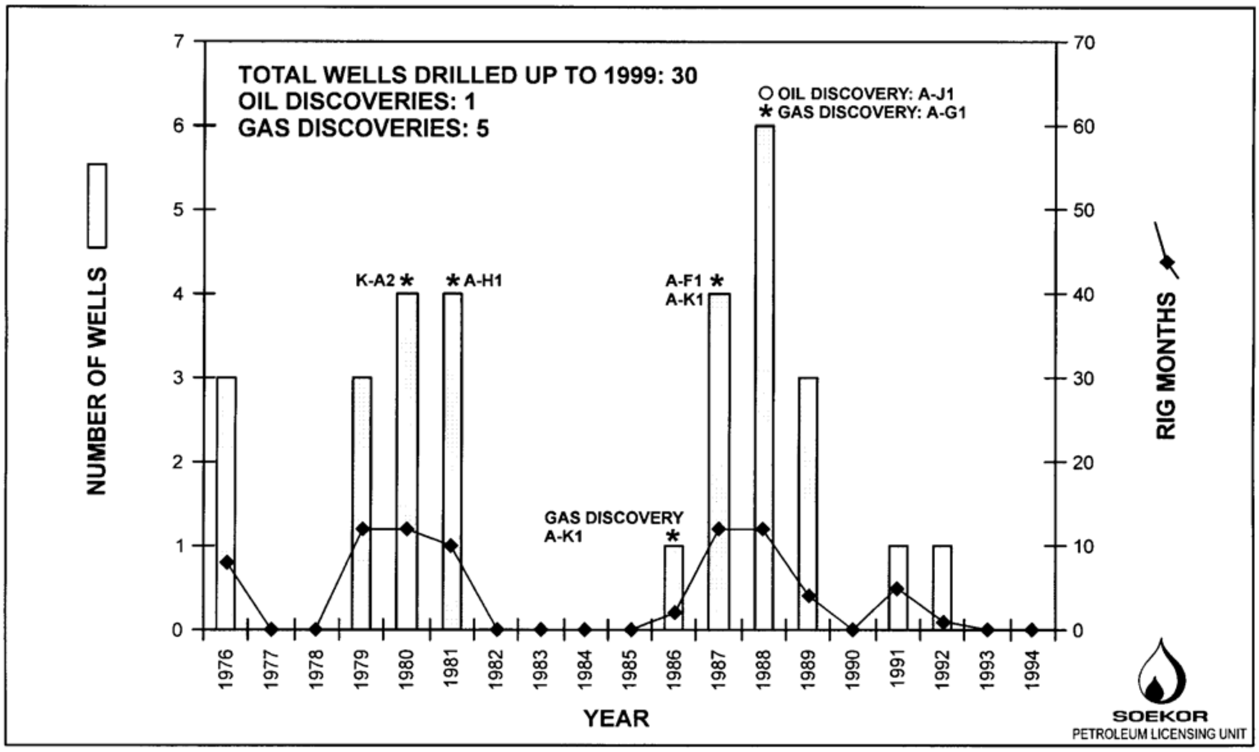


Figure 2.7: South Africa: Exploration wells drilled off the West-coast

The restructuring of SOEKOR resulted in the establishment of three separate entities (see organogram). SOEKOR PTY LTD (the holder of exploration lease OP26), SOEKOR E and P (a separately registered subsidiary company, intended to become commercially independent) and the SOEKOR Petroleum Licensing Unit (a division of SOEKOR PTY LTD). As part of this process, the exploration rights for natural oil of two areas (Blocks 9 and 11a) in which potentially commercial discoveries had been made by SOEKOR Pty Ltd were ceded (effective date October 1994) to SOEKOR E and P.

A powerful motivating factor in expediting the commercial independence of SOEKOR E and P was the government decision to terminate all funding of the company by the end of 1995? To its credit, SOEKOR E and P succeeded in bringing the Oribi (E-BT) oil field on stream in May 1997 and effectively became self-funding from this date. Production averages 24 000 barrels of oil and 15 million standard cubic feet of gas per day. The need to spread the costs and risks of exploration and development in Blocks 9 and 11a was addressed by taking on board Pioneer Natural Resources and Petroleum Ltd as partners in 1998.

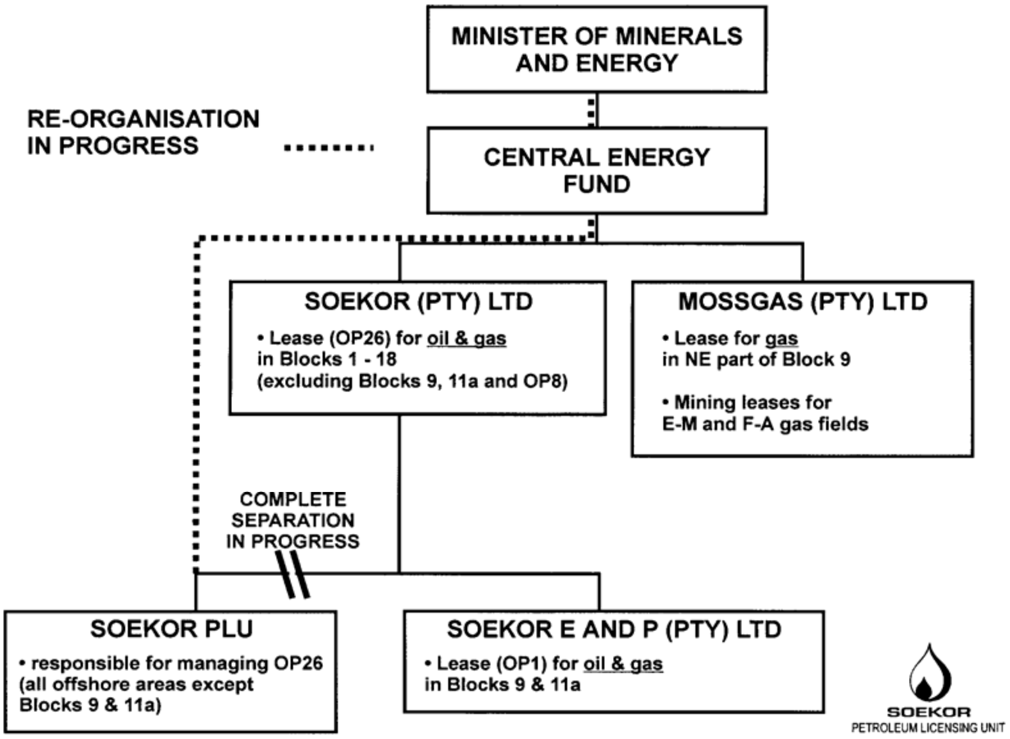


Figure 2.8: Organisation of the South African Petroleum upstream sector

The Oribi project proved robust enough to survive the oil price crisis of 1998/1999 when crude prices tumbled by some 30%. The company is now going ahead with bringing the Oryx (E-AR) oil field into production by mid-2000 and tying it back to the Orca production platform on the adjacent Oribi oil field. The possibility is being assessed of bringing the EBD/ECE oilfield into production by end-2000. The Orca production facility is based on a converted semi-submersible drilling rig. Oil production is delivered to shore with a single shuttle tanker. A major merit of the system is that it can be moved to a new location when Oribi and its satellites are depleted, leaving the seafloor clean of obstructions.

In 1999, the decision was taken to cede to Mossgas Pty Ltd the gas rights to the area around the FA/EM gas fields (basically the northeastern quarter of Block 9), to allow it to explore for gas to extend the life of the FA platform. The development of the EM gas field was also given the go-ahead. Gas and condensate will be exported by 48 km twin pipelines to the FA platform and then to shore in the existing FA pipelines.

After the unpromising start with the un-productive licensing round in 1994, it was decided that a dedicated petroleum licensing unit should be created to focus on the task of marketing the offshore acreage to international explorers. The SOEKOR PLU was accordingly established in 1996 and immediately began actively promoting exploration opportunities to the local and international market.

The critical task of persuading the government to make the commercial terms for explorers consistent with the perceived exploration risks and attractive in the highly competitive international market was successful and bore fruit in 1996, when Phillips Petroleum signed a technical cooperation agreement for the Block 17/18 area (KwaZulu/Natal) that was later successfully negotiated as a 9 year sub-lease (partnered by Sasol, Energy Africa and PanCanadian) in mid-1997. This was followed in the same year by the award of sub-leases to Pioneer Natural Resources (block 7-10/14B) on the South Coast and Anschutz South Africa (Block 2A) on the West Coast.

In addition, a sub-lease for Block 1 is under negotiation and a technical cooperation agreement has been signed with Ranger Oil and partner PanCanadian, for Block 11B/12B on the South Coast.

Table 2.3: South African West Coast Petroleum Exploration Licences (As at June 1999)

LICENCE	OPERATOR	PARTNERS	START DATE	TERM	MINIMUM WORK COMMITMENT
LEASE OP26 (SOEKOR PTY LTD) : all RSA offshore except OP8 and South Coast Blocks 9 & 11a					
SUB-LEASES					
Block 2A	Forest Exploration International	None	18/6/98	7 years	*In the initial 30 month period* : -reprocess 3500 km seismics. - 700 km new 2D seismics. - 200 km^2 new 3D seismics. *At end of each renewal period (30, 30, 24 months)* - reduce area to 50, 25, 15% of original. - after initial 30 month period, drill one well in each of the 3 succeeding renewal periods.
Block 2A	Forest Exploration International	None	18/6/98	7 years	*In the initial 30 month period* : -reprocess 3500 km seismics. - 700 km new 2D seismics. - 200 km^2 new 3D seismics. *At end of each renewal period (30, 30, 24 months)* - reduce area to 50, 25, 15% of original. - after initial 30 month period, drill one well in each of the 3 succeeding renewal periods.
Block 1	Under negotiation				

A new bench mark document is the government's Energy White Paper, published in 1999. As part of the re-structuring of the upstream petroleum sector, the PLU will be registered as an independent professional agency, to be called Petroleum Agency SA. It will report directly to the Central Energy Fund (see above Organogram).

By 1997, one of the consequences of the concentration of petroleum exploration and production in the Bredasdorp Basin (Block 9) was the growing conflict of interest with the trawl fishing industry, particularly as this activity had also increased in intensity and in the extent of the offshore areas that are fished. The conflict centred largely on the issue of old wellheads that had been abandoned (pre-1984) in trawling fairways and the placing of new exploration and production facilities in prime fishing ground. Fortunately, before the conflict escalated, the Department of Minerals and Energy initiated the Agulhas Bank Liaison Committee, which defused the situation. The aims of the Committee are set out in Figure 2.9.

AGULHAS BANK LIAISON COMMITTEE
&
WEST COAST LIAISON COMMITTEE

- The Agulhas Bank Liaison Committee was established by the DME in February 1998 to defuse potential conflict between the trawl fishing and petroleum exploration and production industries.
- It was successful in this and the scope of the Committee was expanded to include all stakeholders.
- Meetings are arranged bi annually by the DME, which provides the secretariat.
- The West Coast Liaison Committee was initiated later in 1998 because of the increasing activities of the offshore diamond prospecting and mining industry.
- Aims of the Committees are to :
    - Open channels of communication.
    - Create improved mutual understanding of each stakeholder's interests.
    - Determine the need and scope for a cummulative environmental impact of all activities in the area (fishing, shipping, mineral and petroleum prospecting and mining).
    - Resolve potential problems timeously.
- Key Industries I organisations are :
    - Fishing industry associations (SECIFA, SADSTIA).
    - Department of Transport (Maritime Division).
    - Marine Diamond Miners Association (MDMA) & direct representation by operating companies.
    - Department of Minerals and Energy.
    - Department of Sea Fisheries.
    - Department of Nature Conservation.
    - Offshore Petroleum Association of South Africa (OPASA), & direct representation by operators.
        - Mossgas.
        - SOEKOR E and P.
        - SOEKOR Petroleum Licensing Unit.

Figure 2.9: ***South Africa: aims and key members of the Agulhas Bank and West Coast Liaison Committee***

Another positive recent development is the establishment of OPASA (Offshore Petroleum Association of South Africa) (Figure 2.10). The organisation will focus on coordinating and promoting matters of common interest to petroleum exploration and production operators and in fostering environmentally responsible operations in the offshore.

OFFSHORE PETROLEUM ASSOCIATION OF SOUTH AFRICA (OPASA)

- Launched in May 1999.
- Membership is limited to operators and partners of companies engaged in exploration and production in the RSA offshore.
- OPASA will provide a forum for formal and informal discussion and information exchange, practical co operation and joint liaison with the State on specific issues.
- A prime objective is to co-operate with the State and other stakeholders in promoting health, safety and sound environmental practices.
- Planned activities include:
    - promoting public awareness of the offshore petroleum industry.
    - promoting compliance with good oilfield practices.
    - promoting care of the environment.
    - liaison with interested affected & parties.
    - pooling resources for emergency response.
    - industry dialogue with the State on operational issues.
- The current chairperson is Dr. Habiger of Phillips Petroleum. The Secretariat is provided by Mr. J. Holliday of SOEKOR PLU.

Figure 2.10: Offshore Petroleum Association of South Africa: Objectives and Activities

Areas of interest

The distribution of seismic data shown in Figure 2.6 reveals where the focus of exploration interest has been. Along the West Coast, the sedimentary succession thins towards the land and over most of the coastline it is too thin to be prospective for oil and gas exploration within at least 20 or 30 km of the shore line. This unprospective strip becomes much wider south of Saldanha and Cape Town because of the broad Agulhas basement arch.

The areas around the existing gas and oil discoveries on the shelf area in water shallower than 400 m and other untested plays and prospects on the shelf area will probably continue to attract attention. The Kudu gas play for example extends south across the border into the RSA offshore. Considerable interest is also directed at the potential of the ultra-deep areas seaward of the 500 meter water depth contour, out to 2000 m and beyond.

CHAPTER 3:

GEOLOGY

Contents

3. GEOLOGY 3.1

Figures

Figure 3.1: Namibia: location of sedimentary basins 3.6
Figure 3.2: Idealised structural dip section for offshore Namibia (from Light *et al*., 1991) 3.7
Figure 3.3: Generalised stratigraphic cross-section through the Orange Basin, South Africa 3.11
Figure 3.4: Orange Basin: maturity of source rocks overlying Early Aptian unconformity 13At1 (from Broad and Mills, 1993) 3.13

Tables

Table 3.1: South Africa: offshore sequence stratigraphic framework (from Broad and Mills, 1993)........... 3.10

3. GEOLOGY

ANGOLA

The sedimentary history of the Angolan continental margin is associated with the Lower Congo and Kwanza Basin development and started in Early Cretaceous times. The African and South American continents which were joined at that time, began an interior rifting process, which ultimately led to their separation, and drifted away from each other. The stratigraphy of these basins has remained remarkably similar from the Barremian to the present day.

The sedimentary fill of these basins is subdivided into three mega sequences overlying a thin pre rift sequence (Lucula Formation). The three, from the base upwards, mega sequences are:

(i) A non marine mega sequence (Neocomian) filling an intracontinental rift. That thick sedimentary section was deposited mainly in deltaic and lacustrine environments

(ii) A transitional mega sequence (Aptian - Albian), deposited discordantly over the previous one. It is dominantly clastic (conglomerate, sandstones and shales of the Chela/Cuvo Formations) and also includes evaporitic deposits (Loeme Formation).

(iii) A marine mega sequence (Albian - Holocene) associated with deposition at the opening of the proto Atlantic Ocean.

The Kwanza and the Lower Congo basins are separated by NE SW trending intra plate transform faults. The Luanda transform Fault limits the Kwanza Basin to the north and further north, the Ambriz transform fault limits the Lower Congo Basin. The individual segments subsided differentially from each other, depending on the sediment load brought in, especially during Tertiary times.

TECTONOSTRATIGRAPHIC EVOLUTION

RIFT PHASE - NON MARINE (LATEST JURASSIC - BARREMIAN)

The “Rift Sequence” overlies a thin pre rift sequence and begins in the Neocomian, with the development of normal basement faulting, trending approximately NW SE. As a result, deep fault bounded lake systems were created containing a wide variety of non marine depositional environments and associated lithofacies. Amongst them, the deposition of the organic rich lacustrine shales of the Bucomazi Formation and its equivalents which provide one of the most prolific source rocks within the South Atlantic Basins.

TRANSITION PHASE - RESTRICTED MARINE/EVAPORITIC (APTIAN)

At the end of the active rifting phase and following an Early Aptian regional erosion event, the proto South Atlantic Ocean began to invade from south to north. A fluvio deltaic to lagoonal/marginal marine sandstone, the Chela (Lower Congo) / Cuvo (Kwanza) Formation, was deposited on a peneplained surface.

It also marks the onset of the "Transitional sequence" with new oceanic crust forming along what became the Mid Atlantic Ridge. These Chela/Cuvo sandstones have generally fair to good reservoir quality, and serve as a major carrier bed system for hydrocarbons generated in the underlying organic rich lacustrine shales.

Truly open marine conditions were not yet established. However, the overlying Late Aptian Loeme Formation, consisting of a series of layered halite and potassium salts, suggests several episodes of desiccation following several marine invasions. This unit is highly mobile through time and the resulting halokinesis has played a dominant role in the structural and stratigraphic trap formation of the majority of the post salt reservoired oil in the Lower Congo Basin.

Additionally, where the Loeme salt is present it provides an excellent seal to vertically migrating hydrocarbons generated in the pre salt section. However, in both the Lower Congo Basin and the Kwanza Basin, most of the oil reservoired above the salt has been fingerprinted to the lacustrine shales of the pre salt rift sequence. It indicates the importance of halokinetic movements that removed salt and created "windows" through which oils migrated vertically.

NERITIC MEGASEQUENCE (LATE APTIAN - ALBIAN)

This phase covers the end of the evaporite deposition. Improved marine connection into the South Atlantic through the Walvis Rio Grande Ridge and extensive shallow water carbonate deposition in the Angolan margin basins are typical of this period.

HEMIPELAGIC MEGASEQUENCE (CENOMANIAN - TURONIAN)

With improved marine connection to the South Atlantic, rising sea level outpaced margin subsidence, resulting in widespread marine transgression in the Late Albian to Turonian interval, with accentuated shelf, slope and basin domains. Clastic reservoirs are well developed locally. During sea level lowstands these were reworked and deposited in the deeper basin.

DEEPENING OCEANIC MEGASEQUENCE (SENONIAN - PALAEOGENE)

From Senonian times, the clastic input was gradually reduced, leading to the development of several condensed sections, with maximum condensation occurring during the Middle Eocene. This strong condensation is accompanied by extensive development of organic rich shales and pelagic oozes.

During the Late Cretaceous to Eocene times, the Lower Congo Tertiary depocentre area was probably a deep basin, relatively starved of sediment. In the Kwanza basin, Eocene shelf extended further westward, probably similar to the present day shelf.

Salt movement and related growth faulting initiated during the neritic phase (Albian) continued throughout as a succession of pulses of varying intensity. In the Lower Congo, it terminated in the Turonian, and was reactivated later during the Tertiary shallowing oceanic phase.

SHALLOW OCEANIC MEGASEQUENCE

From the Mid Eocene to Recent time, climate change, relative sea level fall, increase in clastic influx, subsidence and sediment loading, gravity tectonics with detachment, faulting, rafting and toe compression, all combined to radically alter the depositional regime.

EVOLUTION OF THE SHALLOWING OCEANIC MEGASEQUENCE

The sediment gravitational gliding was initiated from Eocene to Oligocene times. A tectonic tilting episode and/or the loading effect from the suddenly increased sediment overburden may have caused the initial instability. The initial gliding occurred along a master detachment fault, which may be related to a deep seated basement fault and/or the position of the ancient Albian carbonate shelf edge.

Subsequent basinal sediment loading associated with the initiation of the proto Congo River and the Late Oligocene sea level fall (30 Ma), caused fragmentation of the olistholite into several individual rafts, probably along pre existing Albian growth faults. The reconstruction at the end of Oligocene times shows that a series of rafts were formed, subsequently covered by a significant amount of Late Eocene Oligocene sediments.

Individualisation of the smaller rafts continued during Early Miocene times, and is associated with contemporaneous westward prograding slope and basinal sediments.

During Middle Miocene times, shelf sediments prograded into the basins. Because of the rafts continuing movement, a very characteristic suite of antithetic faults developed on their trailing edge, creating a major trough system. Typically, these antithetic faults become younger towards the centre of the trough. Along the leading edge of the rafts, normally a major synthetic fault developed.

During Late Miocene times, the major trough system continued to inhibit further shelf progradation and ponded sediments on the slope.

At the Mio Pliocene boundary, increased gravitational gliding of the rafts is observed. This triggered the development of a completely new fault system along the initial master fault escarpment. The new synthetic fault system consists of a series of linked low angle growth faults becoming younger westward and soling out into the Middle Miocene condensed section.

As Tertiary troughs were filled in, they tended to migrate westwards with time. Westward younging of trough systems as seen in the Kwanza Basin, again indicating relatively high sediment input.

In addition to the extensional structures, inversion, compressional folds, thrust faults and salt structures mark the toe of the gravity gliding and spreading system.

Geochemistry

Reservoirs in post Albian discoveries of the Lower Congo Basin become progressively younger from east to west. Their size is also bigger than those on the platform, with giant discoveries made in the Lower Congo Basin. Available scouting data suggests that the platform-related accumulations are derived from late oil to gas mature source rocks.

Potential source rocks have been identified in diverse stratigraphic units, ranging from the pre salt, mainly within the Bucomazi and locally in the Chela Formations, to the Cretaceous and Tertiary Iabe Formation.

Analyses of the oils found in the southern part of the Lower Congo Basin suggest that, on the platform, oil originated from a pre salt source, while in the deep offshore oil is sourced from mature Iabe source rocks.

Slick maps from satellite radar images show numerous seepages in the deep and ultra deep offshore Angolan Basins. In the Lower Congo Basin, the seepages have been identified as being closely related to the major fault system.

The same maps show no or restricted seepages in the deep offshore Kwanza Basin. One can interpret this observation in relation to the maturity (and burial) of the Iabe source. This source rock is deeply buried and obviously mature in the Lower Congo basin, producing a number of seeps. This may not be the case in the Kwanza Basin.

NAMIBIA

Four sedimentary basins occur offshore. From south to north these are the Orange, Lüderitz, Walvis and Namibe Basins (Figure 3.1). The Orange Basin extends southwards into South Africa waters and the Namibe Basin continues northwards into the Angolan offshore. The Walvis and Namibe Basins are separated from each other by a prominent ridge of old, submarine volcanoes, the Walvis Ridge. This ridge has been a major divide throughout most of the history of the South Atlantic Ocean and we find the sedimentary successions to the north and south of it differing very significantly. The average width of the continental shelf is about 100 km south of the Walvis Ridge and about 35 km north of it.

The structural framework along the whole Namibian coast consists of inner intermittent eastern half grabens (thrust-ramp grabens in Figure 3.2) of variable depth and a major, almost continuous outer or central half graben that is up to 100 km wide and almost 10 km deep in places. The inner and outer grabens are separated by a medial hinge line. The central half graben is bounded in the west by a marginal basement ridge (Light e*t al*., 1991, 1993). The Namibe Basin is highly structured with several half grabens, a well developed marginal ridge over which drape of the sediments has produced several large four-way dip closures.

The stratigraphic succession can be subdivided into five main units: Pre-rift (or Basin & Range of Light *et al.,* 1991), Synrift I and II, Transitional and Thermal Sag.

The Pre-rift succession probably consists of rocks of the Carboniferous to Cretaceous Karoo Sequence. It rests on an older, highly deformed metamorphic basement. The pre-rift Karoo Sequence is believed to occur extensively offshore Namibia, particularly at the base of the succession in the central half graben in the Lüderitz and Orange Basins. Karoo rocks crop out on the coast of northern Namibia but they are difficult to recognise on seismic sections of the adjacent regions in the Walvis and Namib Basins.

The age of the base of the Synrift I is unknown. The synrift succession is fairly readily divisible into Synrift I and Synrift II megasequences in the central half graben in the Orange and Lüderitz Basins. The updip pinch out of the Synrift II succession against the medial hinge line is the stratigraphic trap setting for the Kudu gas. This pinch out can be traced through the Orange Basin almost to the Walvis Ridge. The Synrift II succession thickens significantly northwards into the Walvis Basin. Synrift rocks in the Namibe Basin are relatively thin. Drilling offshore Namibia has penetrated only to the top of the synrift where basalts and some interbedded sediments were intersected.

The Transitional sequence was deposited during the early to mid Cretaceous when rifting gave way to break up and the start of continental drift was accompanied by the first marine incursions over the newly developed continental margins. Basal transgressive sands are overlain by deep-water, organic rich marine shales. As continental drift continued and settled in and the continental margins sagged below sea level, deposition of the Thermal Sag succession took place and continues today. It consists of the remainder of the Cretaceous sequence and the whole of the Tertiary succession. South of the Walvis Ridge, the Cretaceous is thick and the Tertiary thin, although the latter thickens northwards. North of the Walvis Ridge, the Cretaceous is relatively thin but the Tertiary sequence thickens very rapidly, particularly into deeper water.

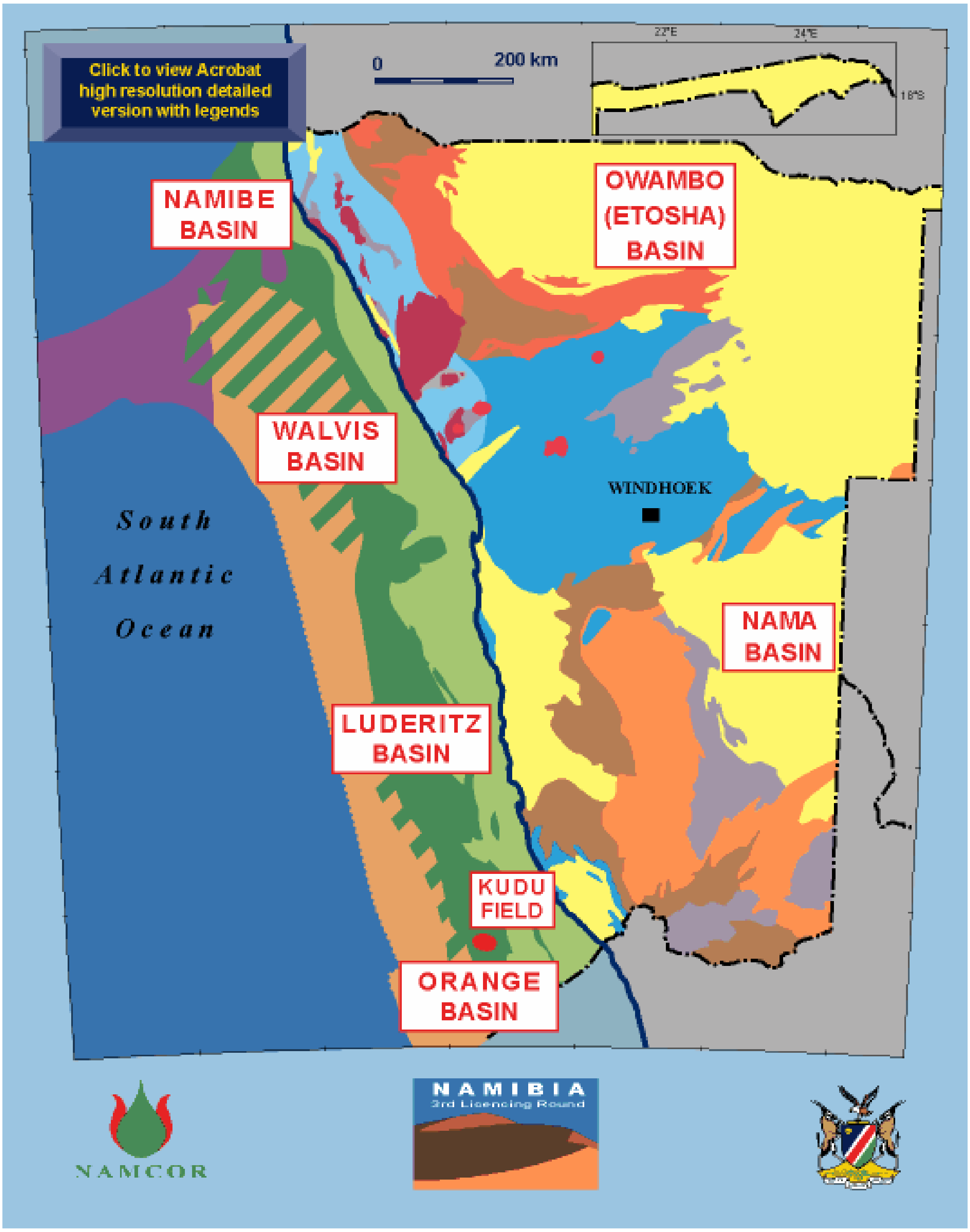


Figure 3.1: Namibia: location of sedimentary basins

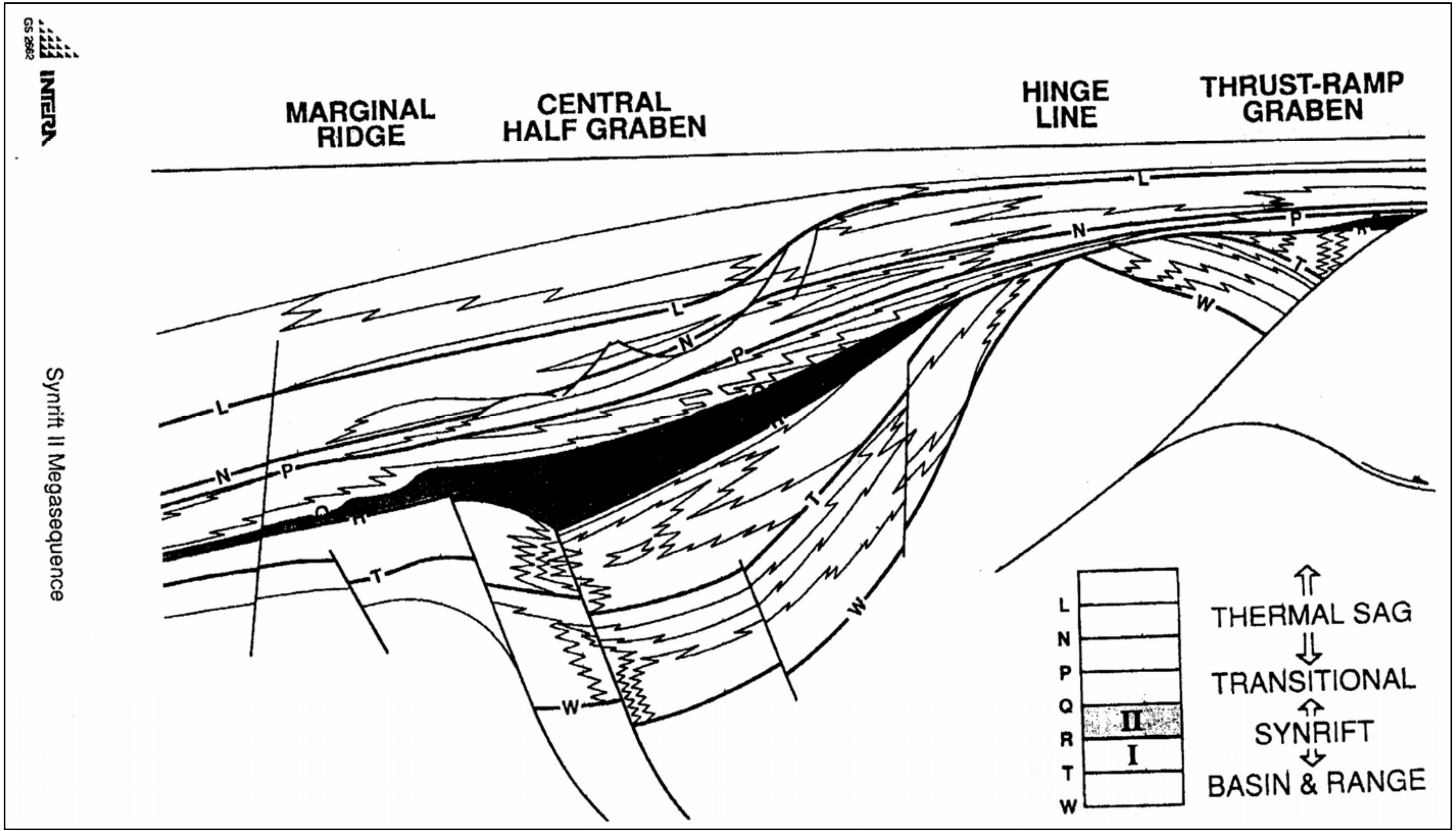


Figure 3.2: Idealised structural dip section for offshore Namibia (from Light et al., 1991)

Petroleum potential

Source rocks are (i) Permian, oil-prone black shales of the Karoo age Whitehill Formation and associated gas-prone, bituminous shales (known at present only onshore), (ii) potential synrift lacustrine shales such as those intersected in the A5-1 well in the eastern Orange Basin of South Africa, (iii) Barremian and lower Albian oil-prone and gas-prone shales intersected in the Kudu wells, and (iv) Cenomanian to Turomian oil-prone shales as intersected in DSDP wells, in some of the Namibian exploration wells and in deeper water exploration wells off the west coast of South Africa.

In the light of recent deep-water discoveries in Angola and West Africa, it is interesting to look at the location of deep-water reservoir sands offshore Namibia, particularly in the mid to upper Cretaceous and lower Tertiary sections which have many similarities to the Angolan and West African offshore successions of the same age. Besides delineating areas containing potential delta plain facies in the synrift in the Walvis Basin and dune facies in the same interval in the Orange and Lüderitz Basins, Light *et al*. (1991), in an internal report to NAMCOR, also delineated regions of potential channel sands in the Transitional Sequence in the Lüderitz Basin, deep marine fan sands at the base of the Thermal Sag succession (mid Cretaceous) and channel and deep marine fan sands in the upper Cretaceous and lower Tertiary in all four basins. Most of these deposits, many of which are mounded, occur above the Barremian-Aptian and Cenomanian-Turonian source intervals. Some of the channeling, and the fill thereof, may be due to slumping but clear differential compaction over many fan-like bodies suggests the presence of sand. Most of these sands occur in water depths between 200 and 1000 m in the Walvis Basin and between 200 and 2000 m in the other three basins. Albian shelf carbonates with up to 25% porosity have also been intersected by drilling (Holtar and Forsberg, 1997).

With a total of only 12 widely spaced offshore wells, the geology of the Namibian is not well known but the Kudu gas and the various source rocks prove that there is a working petroleum system offshore.

Petroleum resources discovered to date

The Kudu 4 and 5 wells have added to the success of the Kudu 1 and Kudu 3 wells and encountered large reserves of high-pressure gas. Shell announced in 1997 that testing of the Kudu 4 well had established an in situ gas reserve of 1.8 TCF. A feasibility study to use this gas to drive a 750 MW combined cycle power station at Oranjemund is still in progress. Most of the other exploration wells intersected oil- and gas-prone source rocks of various ages (critical for the generation of oil and gas) as well as reservoir rocks of different types and ages. Holtar and Forsberg (1997) believe that the deepest reservoir intersected in the first well in area 1911, in Albian shelf carbonates, once contained oil but that this had escaped through time. The challenge now is to find similar reservoirs that still contain oil or those into which the oil has migrated.

SOUTH AFRICA

The offshore basins of South Africa lie along the southern margins of the African plate. They originated in the middle to late Jurassic during the breakup of southern Gondwana.

The western margin of South Africa is a divergent plate margin underlain by synrift grabens, whereas the southern and eastern margins are pull-apart grabens truncated by a major transform fault.

This major lineament, known as the Agulhas-Falkland Fracture Zone, is 1 200 km long. It began right lateral movement at the time of continental separation. This resulted in widespread structural deformation of adjacent basins and accounts for the wide variety of structural traps.

The West Coast Margin extends from the southern tip of the continental shelf to the Namibian border and includes most of the Orange Basin. The Outeniqua Basin extends from Cape Town to Port Elizabeth and contains the Bredasdorp, Pletmos, Gamtoos, Algoa, and Southern Outeniqua sub-basins.

The Durban and Zululand basins occupy the narrow continental shelf north of Durban and from the southern part of the Mozambique basin.

West Coast Margin

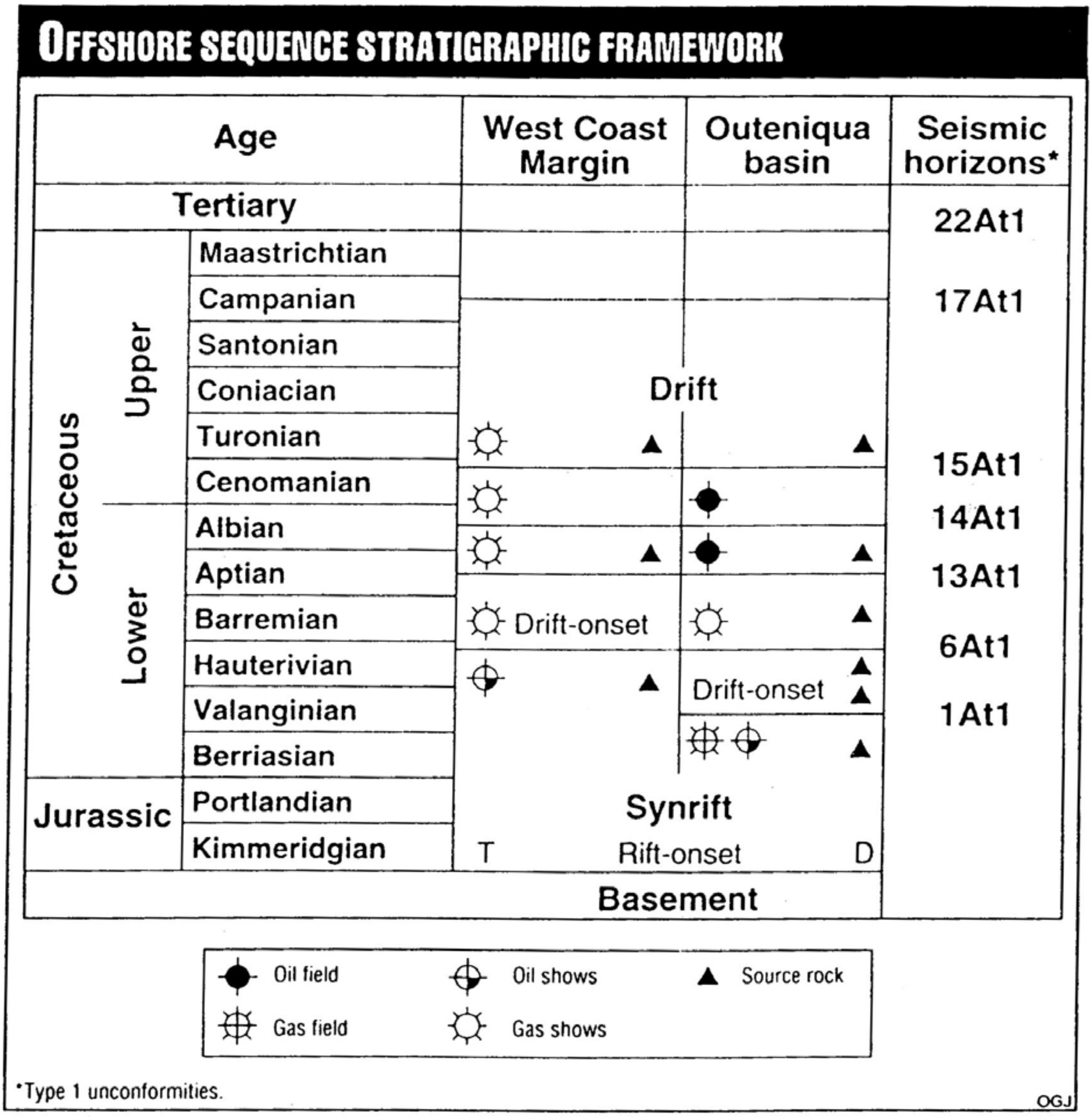
The West Coast Margin covers approximately 130,000 sq km and is significantly underexplored. The Orange Basin is rated by SOEKOR as having good hydrocarbon potential (Figure 3.3). Half of the 30 wells drilled encountered some form of hydrocarbons. Gas has been found in the drift succession and oil in the synrift succession (Table 3.1). Trapping mechanisms in the synrift are generally stratigraphic, whereas in the drift traps are predominantly of a structural and combination type.

A recent seismic survey in the deep-water areas of the West Coast Margin has revealed a number of prospects in water less than 450 m deep. The area represents a large, relatively untested frontier basin with known hydrocarbon accumulations and the potential for giant fields.

Reservoirs

Reservoirs in the synrift succession sandstones exhibiting excellent porosity and permeability have been encountered at depths of up to 4 600 m, although in some areas porosity and permeability have been degraded by secondary silicification.

Table 3.1: South Africa: offshore sequence stratigraphic framework (from Broad and Mills, 1993)



OFFSHORE SEQUENCE STRATIGRAPHIC FRAMEWORK

Age			West Coast Margin	Outeniqua basin	Seismic horizons*
Tertiary					22At1
Cretaceous	Upper	Maastrichtian			
		Campanian			17At1
		Santonian	Drift	Drift	
		Coniacian			
		Turonian	☼ ▲	▲	
		Cenomanian	☼	●	15At1
	Lower	Albian	☼ ▲	● ▲	14At1
		Aptian			13At1
		Barremian	☼ Drift-onset	☼ ▲	
		Hauterivian	⊕ ▲	▲	6At1
		Valanginian		Drift-onset ▲	1At1
		Berriasian		⊞ ⊕ ▲	
Jurassic		Portlandian	Synrift	Synrift	
		Kimmeridgian	T Rift-onset	D	
Basement					

● Oil field
⊕ Oil shows
▲ Source rock
⊞ Gas field
☼ Gas shows

*Type 1 unconformities.

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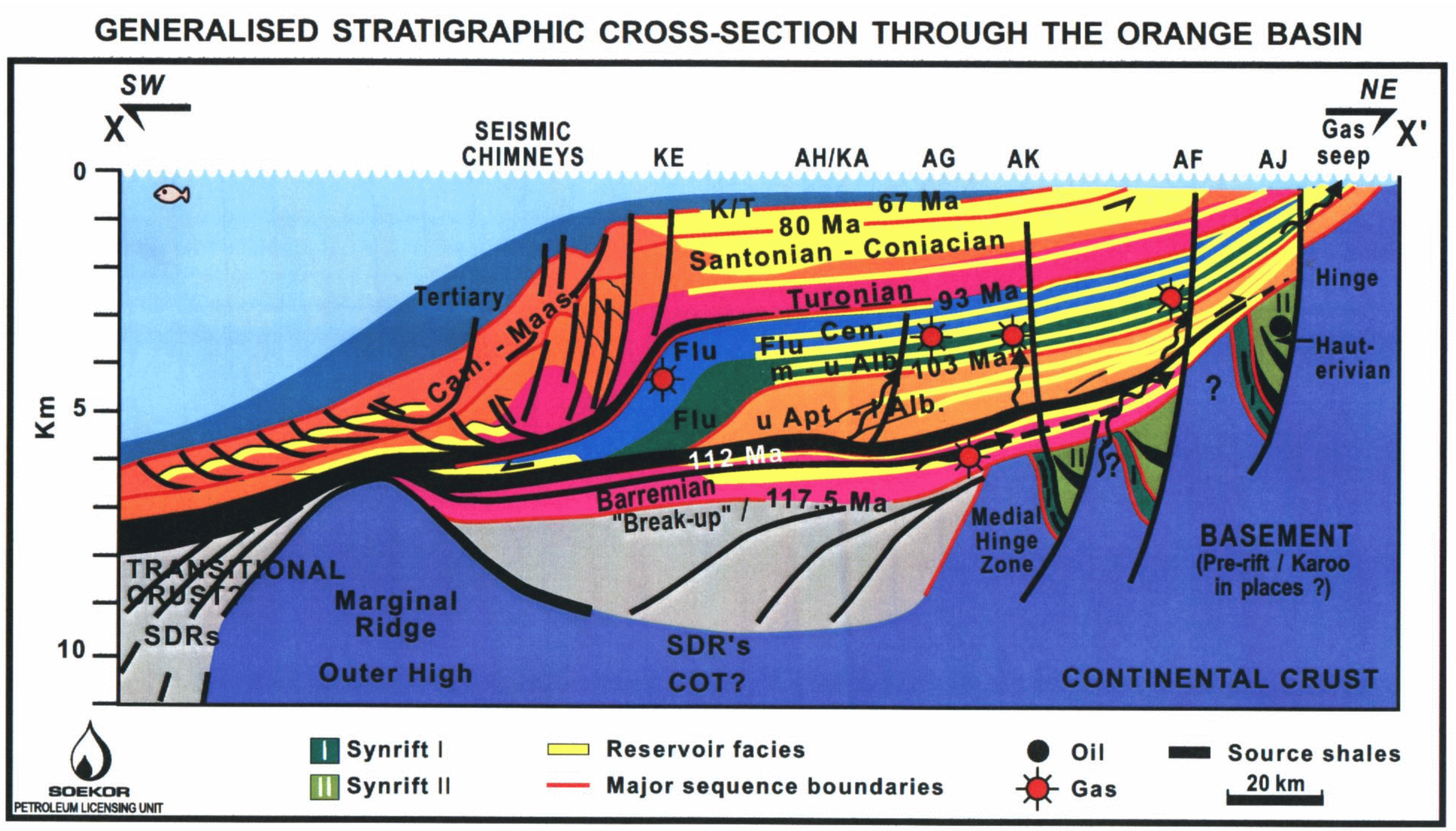

Figure 3.3: Generalised stratigraphic cross-section through the Orange Basin, South Africa

Source rocks

Three source rock intervals have been identified. Mature, oil-prone, lacustrine source rocks up to 60 m thick are present in the synrift interval. They had an original hydrocarbon potential of 9-11 kg/ton, locally exceeding 40 kg/ton.

Directly above the Early Aptian unconformity 13At1, source rocks are regionally developed and range from gas-prone on the shelf to oil-prone farther west. They are up to 90 m thick and had an original potential of 3-9 kg/ton. In the Namibian sector of the basin they are up to 140 m thick with an original oil potential of up to 11 kg/ton. Beyond the shelf break maturity levels are expected to decline as the overburden thins.

Gas prone source rocks averaging 30 m thick were deposited during the global Cenomanian/Turonian oceanic anoxic event immediately above the 15At1 unconformity. The potential of these source rocks is expected to improve basinward where they may become oil-prone.

Traps, migration

Traps tested thus far include domal and fault-controlled closures and stratigraphically defined lowstand plays and pinchouts.

Several play types have not been adequately tested, and plays located in water depths greater than 450 m require further evaluations.

Migration routes in the basin vary from short and direct in the grabens to medium to long distance farther offshore.

Conclusions

Where drilling has taken place there is evidence for hydrocarbons, reservoir sandstones, source rocks, traps, seals and migration. The deeper parts of the Orange Basin may be regarded as prime frontier areas with the potential for giant fields.

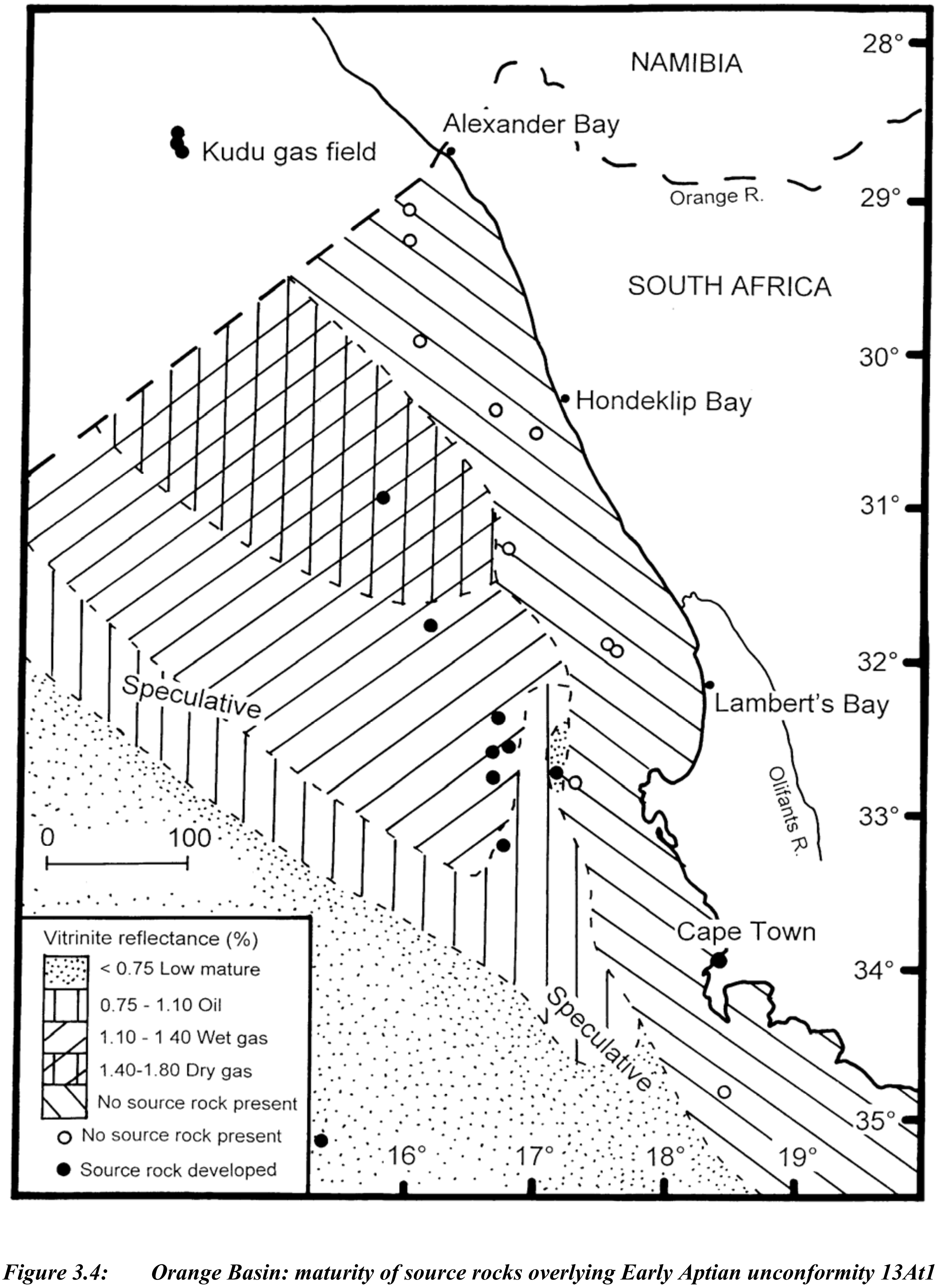

Figure 3.4: ***Orange Basin: maturity of source rocks overlying Early Aptian unconformity 13At1 (from Broad and Mills, 1993)***

CHAPTER 4:

SEISMIC SURVEY TECHNIQUES

Contents

4. SEISMIC SURVEY TECHNIQUES 4.1
4.1 Introduction 4.1
4.2 Environmental effects of seismic surveys 4.2

4. SEISMIC SURVEY TECHNIQUES

4.1 Introduction

When seismic surveying first started many decades ago, dynamite or similar explosive materials were the only source of artificial seismic energy used B all highly dangerous and very destructive to the marine environment. In the 1960s, these materials were replaced by a variety of energy sources and by the late 1960s air guns had become the most widely used energy source (Mott-Smith *et al*., 1968). The principle of the air gun is described in detail by Lugg (1979). An air gun releases a high-pressure air bubble into the water thereby generating an acoustic shock wave. A single air gun is not powerful and it is necessary to deploy the air guns in arrays of up to 40 guns. The combined volume of such an array can be up to 4 750 cubic inches (77.9 litres). The array is towed about 30 to 50 m behind the seismic vessel between 4 and 10 m below surface. Air bubble release from all the guns is synchronise in order to produce a single acoustic pulse with enough energy to penetrate the sub-seabed strata to a depth of several kilometres.

The maximum output of typical air gun arrays is in the frequency range of 10 to 300 Hz (McCauley, 1994). The rise time (build up) of the air gun acoustic signal is 1 to 5 milliseconds which is 10 to 50 times slower than that of dynamite. It also has a lower peak amplitude. As a consequence, air guns do not harm anything beyond about 1 metre from the gun (Weinhold and Weaver, 1973; Holliday *et al*., 1987).

Dynamite has never been used for offshore seismic surveying in Namibia and South Africa. Various energy sources, patented by different geophysical survey companies, were used. The aquapulse was used to acquire 3 194 km of seismic data in four jobs between 1968 and 1969; the vapour choc was used to acquire 6 749 km of seismic data in four jobs between 1972 and 1974; the air pulser was used to acquire 3 711 km of seismic data in three jobs between 1969 and 1973. Air guns were used for the first time in 1969 and by 1978 had acquired 23 565 km of data in 19 jobs. These statistics clearly demonstrate that air guns are the energy source of choice in the industry.

The aquapulse, or sleeve exploder, exploded propane or butane gas in a thick-walled rubber bag held below the surface. Waste gases were vented into the air. The vapour choc, or steam gun, injected superheated steam under high pressure into the water (Sheriff, 1974). The air pulsar probably functioned in a similar way to the vapour choc using air under high pressure instead of steam.

The acoustic signals from the air guns are reflected back to the surface by the different geological layers below the seabed and are recorded by hydrophones in a "streamer" towed behind the seismic ship. Streamers range from 1.2 km up to 6 km in length. The streamer is a flexible plastic tube full of conductive wiring and containing hundreds of hydrophones often spaced only 12.5 cm apart. The streamer is made up of sections between 6 and 25 m in length for ease of repair. These sections are connected to each other to make up the full length of the streamer. The streamer is filled with diesel or kerosene for buoyancy. During seismic surveys, guide vanes ("birds") keep the streamer at the required depth, usually 10 m below surface.

The geophysical survey vessel generally travels at a rate of 4 to 6 knots when surveying and the guns are discharged every 25 metres. The seismic reflections from every layer in the subsurface are recorded by each of the hydrophones. Thus, huge sets of data are recorded by the onboard computers. Processing of this data is done onshore on supercomputers to produce profiles of the sub-seabed geological structure along the length of each seismic line. Generally, it takes a month of supercomputer time to process 1 000 km of seismic data.

4.2 Environmental effects of seismic surveys

Sources of sea noise may be of biological, physical or anthropogenic origin. The major sources of non-biological noise likely to be encountered in the sea in the Benguela Current region are wind, shipping traffic, thermal agitation, water turbulence, rain and surf. These sources act independently with each having a particular spectral character. The temporal character of most of the sources is of continuous noise fluctuating over a time scale of hours to days.

The production and interpretation of acoustic signals by marine animals is a common phenomenon (Hawkins and Myrberg, 1983; Tavolga, 1965). Sounds of biological origin are produced in a variety of circumstances such a reproductive displays, territorial defence or in echolocation. There are no published data for biologically produced sea noise in western and southern African waters.

It is against this noisy background that the effects of marine geophysical (seismic) surveying has to be assessed.

Numerous studies have been carried out on the effects of air guns on fish and marine mammals (summarised by Bowles, 1990, and McCauley, 1994).

Kosheleva (1992) reports no damage to fish within 0.5 m of various sized air guns whereas Booman *et al.* (1992) report a 15% lethality at 0.9 m from guns but no observable damage at 1.3 m.

Rock fish showed changes in behaviour when exposed to air gun discharges (increased general activity, changes in schooling behaviour and position in the water column) or showed alarm or startle reactions (Pearson *et al*., 1992). This behaviour ceased late in the exposure period or within a few minutes after the discharges ceased indicating firstly some degree of acclimatisation to the disturbance and secondly that effects were transient (Pearson *et al*., 1992). Chapman and Hawkins (1969) record alarm responses and changes in schooling behaviour. Fish response to approaching vessels (i.e. no air guns) varies. McCauley (1994) suggest that the general response is one in which the fish move away to a comfortable distance from the vessel (or air gun array) but some fish change their schooling behaviour by either forming tighter schools, by the schools rapidly descending or veering away, by increasing swimming speeds in schools or by panic fleeing resulting in break up of the schools (Buerkle, 1974; Misund, 1993; Olsen *et al*., 1982a, Olsen *et al*., 1982b). Polar cod start to swim away when the vessel is still 250 m away (Olsen *et al*., 1982a). In contrast, some species of large pelagic fish appear to show little avoidance behaviour and actually attack the hydrophone streamer (Colwell and Coffin, 1987). Other studies show fish acclimatising to the air gun releases and not dispersing significantly (Bowles, 1990). Studies in Norway have shown that commercial catches of fish are reduced to varying extents in areas where seismic surveys are taking place but that the fish begin to return within five days of completion of the survey (Dalen and Knutsen, 1986; Engås *et al*., 1993). At one stage, reduction of cod stocks in Norway were blamed on seismic surveys but after several years during which the amount of seismic acquired had increased each year, the cod stocks had increased to such an extent that the fishermen were pleading with government to increase the quotas for cod (pers. com. J. Dalen, 1994). Marine mammals hear the repeated firing of the air guns and many swim away from the approaching seismic vessel (McCauley, 1994). Sasol (1992), however, point out that in their seismic surveys off South Africa, they have often observed seals and dolphins playing alongside operating air guns.

Swan *et al*. (1994, p. 6) conclude that “Localised displacement of pelagic animals will have a minimal effect on their population status. Interruption to breeding events will only be important if the population in question has few, concentrated breeding aggregations which are susceptible to dispersal or masking of acoustic cues by seismic surveys.” They also record little or no disturbance to whales.

Studies of cod (*Gadus morhua*) eggs, larvae and fry have shown no damage at distances of 1 to 10 m from a large air gun (8.61 litre capacity) other than the loss of balance in 110Bday fry for a few minutes (Dalen and Knutsen, 1986). Booman *et al*., (1992) could not detect any damage to eggs and larvae located at a distance of 2 m from air guns. On the other hand, Kostyuchenko (1971) found fish eggs damaged up to a distance of 5 m from a 2 050 psi air gun.

The air guns are towed at depths of between 4 and 10 m below surface. Eggs and larvae tend to concentrate at the thermocline which in Namibian waters is commonly at a depth of around 30 m, i.e. well out of the range at which air guns will have a lethal affect on eggs and larvae (M O’Toole, Ministry of Fisheries and Marine Resources, Namibia, pers. com.).

From the above brief survey, it is apparent that eggs, larvae and fry are at greatest risk because of their inability to take avoiding action. In general, however, only those within one metre of the air guns are likely to suffer lethal damage and “… actual numbers affected should be very small compared to natural fish larval mortality rates and their overall population size” (McCauley, 1994). Swan *et al*. (1994) concur with Darracott (1985) in concluding that “… air guns do not pose any significant hazard to marine life … in the offshore environment.” “This … is borne out by the almost total lack of reports of any such harmful effects.”

Seismic surveys are often briefly interrupted by seals, sharks or large pelagic fish biting the streamers. Since a streamer is made up of many short sections, repairs are quick and very little diesel or kerosene escapes into the environment. Being volatile, this also evaporates quickly.

In all three Benguela Current countries no adverse effects of seismic activities have been reported or recorded.

Disturbance of fish during spawning would appear to be of possible concern during seismic operations in the Benguela Current region and it may be desirable to schedule seismic operations to avoid spawning areas and periods. However, no literature on the effects of seismic operations on the success or otherwise of spawning could be found so it is uncertain whether the scare affects of air gun discharges would be result in less successful spawning when this is one of the most powerful driving forces in nature.

CHAPTER 5:

EXPLORATION DRILLING

Contents

5.1 Introduction 5.1
5.2 Pre-drilling site surveys 5.2
5.3 The drilling operation 5.2
5.4 Well testing 5.4
5.5 Plugging and abandonment of exploration wells 5.4
5.6 The drilling mud 5.4
5.7 Cement 5.6

Tables

Table 5.1: Section and casing depths and volumes and weights of cuttings for a typical offshore well 5.2

5. EXPLORATION DRILLING

5.1 Introduction

Exploration drilling offshore in the Benguela Current region has taken place between the coast and 140 km offshore in water depths ranging from 170 to over 1500 m. Semi-submersible rigs anchored to the seabed drilled the wells in shallower water whereas dynamically-positioned drillships drilled the wells in deep water. The latter were kept heading into the swell and positioned above the wellhead by thrusters controlled by an onboard DGPS computerised positioning system which received signals from passing satellites every few seconds.

The semi-submersible rigs are generally served by two supply boats. One or the other of these is on 24-hour standby at the rig in case of emergencies. Being anchored, a rig is not able to move off location quickly if something goes wrong with the well. While one of these boats is on standby at the rig, the other would be plying back and forth between the supply base and the rig bringing in supplies and equipment and taking back waste and unused equipment. In the case of the drillships which are much more mobile and manoeuvrable, only one supply boat/standby boat is used. There are times, therefore, when there is no boat on standby at the drillships. Since drillships are able to carry much more equipment than the semi-submersible rigs, there is no need for more than one supply boat.

Helicopters are used continuously to facilitate rapid access to rigs, for crew changes, for transporting inspection and management personnel and for small items of equipment, and for emergencies. Mostly two helicopters are used but only one is allowed in the air at any one time for safety reasons.

Drilling lasts between 45 and 90 days depending on the depth of the well and the drilling problems encountered. Drilling is a continuous, 24-hour operation. Between 70 and 90 people will be on the rig at any one time. A well is drilled in several sections, the widest and shortest at the top and the narrowest at the bottom. The penultimate section of the hole is often the longest. Table 5.1 gives a rough indication of the different lengths of each section of a typical well might be, the actual lengths being determined by the geology and the conditions encountered during drilling. Much of the upper two sections of the well is drilled in soft, unconsolidated or semi-consolidated sediments containing as much as 30% sea water. Rock cuttings in this part of the well (which are washed out directly onto the seabed) would therefore be relatively limited and very variable in amount. However assuming that the rest of the well is drilled in consolidated sedimentary rock, the amount and weight of cuttings for an average well would be about 1 000 tonnes (Table 5.1).

Table 5.1: Section and casing depths and volumes and weights of cuttings for a typical offshore well

HOLE SECTION (inches)	SECTION AND CASING DEPTH (metres)	SECTION LENGTH (metres)	CUTTINGS VOLUME (m^3)	CUTTINGS WEIGHT (tonnes)
36	65	65	43	95 (mud)
26	400	335	116	290 (mud + cuttings)
17½	1450	1050	165	45
12¼	3500	2050	158	426
8½	4000	500	19	50
		Total	501	1300 (about 300 mud, **1000** rock cuttings)

5.2 Pre-drilling site surveys

Drilling is preceded by a site survey in the area of the proposed well to determine the nature of the seabed and the first kilometre or two of the sub-bottom strata. This is essential for planning of the anchoring pattern and for detecting any shallow drilling hazards. A site survey normally includes a very localised, high-resolution seismic survey with a short streamer and relatively small air guns, a side-scan sonar survey, a sub-bottom profile survey and collecting of bottom samples. The sub-bottom profile survey is by means of a sparker or boomer, both of which create low-energy sound waves by means of an electrical discharge inside the submerged sparker or boomer. The sound waves penetrate the seabed for a few metres and together with the bottom samples help to reveal the nature of the seabed, whether soft or relatively hard sediment. The seismic also helps in the study of the seabed but it usually also reveals the presence of shallow gas which can be a serious hazard in the initial stages of drilling. If shallow gas is detected, the well site will be relocated off the occurrence. The side-scan sonar provides an image of how smooth or rugged the seabed is.

5.3 The drilling operation

After anchoring, the first section of the well is drilled through a steel temporary guide-base that is set on the sea floor. The guide-base is connected to the drilling rig by four steel guide-lines which allow the drill bit to be guided into the well through the guide-base. The 36-inch diameter hole is drilled with sea water as the lubricant. Seawater is pumped down the hollow drilling rods (the drillstring). The sediment and rock chips (cuttings) from the well are washed out of the hole by the flushing action of the sea water being pumped in and are deposited on the seabed around the well bore. This wide section of the well is usually not more than 30 m deep. When the target depth has been reached, a continuous section of 30-inch casing is lowered into the hole and cemented in place over its full length. To ensure complete cementation of the space between the well bore (the outer wall of the well) and the casing, a slight excess of cement is used. Any excess cement then oozes out at the top of the well onto the seabed. Four steel guide posts extend 4,6 m upwards from the corners of the permanent guide-base, and steel guide-lines extend from their tips to the drilling rig to assist in guiding equipment to and from the seafloor.

Quick setting cement is used and once this has set (in about 24 hours) drilling of the next section of the well, 26 inch, starts. This section will go down several hundred metres and ideally will stop in firm (competent) sediments. A continuous section of 20-inch casing is lowered into the well and cemented in place from top to bottom. Again excess cement is used to ensure complete cementation and any excess oozes out onto the seabed. A permanent guide base (3,6 m in diameter) is bolted to the top of this casing. Once the cement has set, a high-pressure leak-off test is performed. This tests the quality of the cement-rock and cement-casing seals as well as the strength of the rock/sediment into which the casing is cemented. This test is critical since these seals and the enclosing rock must be able to withstand the high pressures of any fluids that may be encountered deeper in the well.

The Blow Out Preventer (BOP) is then lowered onto the guide plate and fastened to the plate and the top of the 20-inch casing. BOPs typically are about 13 m high and consist of a series of valves and shear rams which can be closed within seconds if control of the well is lost if, for example, high pressure fluids are encountered unexpectedly. The marine riser is then fastened to the top of the BOP. It is similar to a continuous length of casing that extends all the way up into the rig. The BOP is extensively tested before drilling resumes to ensure every part of it is functioning according to specification.

At this stage the drilling fluid is changed from sea water to a water-based drilling mud. This is largely sea water containing various additives which serve the purpose of adding weight to the mud in order to prevent blow outs, of modifying its properties to assist with the drilling and of helping to prevent the uncased lower part of the well from collapsing. Like the sea water, the drilling mud is pumped down the inside of the drillstring and returns back to the rig through the casing and the marine riser. At this stage, for the first time, all drilling fluids and cuttings are returned to the rig.

Three more sections of hole are drilled, a 17 2-inch, a 12 3-inch and an 8 2-inch section. 13 3/8-inch casing is cemented into the 17 2-inch section and 9 5/8-inch casing in the 12 3-inch section. The BOP is thoroughly tested again before the deepest section of the hole is drilled since this is the section in which hydrocarbons are expected. If hydrocarbons are present, a 7-inch production liner will be cemented into this section of the hole.

Before each section of casing is lowered into the well, the uncased section of the well is logged by lowering various geophysical instruments into the well. These measure various physical properties of the rocks and help to characterise the rocks and aid in detecting petroleum and in correlation between wells. Two of these instruments, the density and neutron logging tools, contain medium energy radioactive sources and measure the porosity of the formations they pass through. These tools are kept and transported in specially designed storage containers which remain secure and locked at all times. Only specially trained and authorised engineering personnel are permitted to handle them using special handling techniques. Handlers wear personal monitoring devices to measure any unusual exposure. When in use, the drill floor is secured and only key personnel are allowed in the area. The containers are locked away in a special storage area on the rig with the least risk of explosion, fire and exposure. A log is maintained of all access to the container and tools.

5.4 Well testing

Hydrocarbon-bearing zones need to be tested to determine formation pressures, the volumes of hydrocarbons present, the yield and the commercial viability. This is done by perforating the 7-inch liner at the level of each hydrocarbon-bearing formation and allowing the hydrocarbons to flow to the surface under very carefully controlled conditions. On the rig the hydrocarbons are led out to a high-efficiency burner located at the end of a flare boom suspended over the water as far as possible from the rig. The burner must ensure the maximum combustion of the hydrocarbons. Flow rates are carefully controlled and measured over varying lengths of time. Flow tests may take several days.

5.5 Plugging and abandonment of exploration wells

Exploration wells, whether dry or “showing” hydrocarbons, must be plugged and abandoned in a safe manner. Even the early discovery wells in a petroleum field are usually plugged and abandoned and not used for production. Plugging and abandonment involves the placing of two or more cement plugs between 100 and 150 m thick in the well. These are placed opposite and above all porous formations irrespective of whether they contain water or hydrocarbons. The final plug is placed close to the top of the well and just below the seabed. The final drilling mud, being the most dense of all the muds used in the well, is left in the well between the cement plugs and therefore also prevents fluids from escaping from the surrounding formations into the wellbore at some time in the future. After the BOP has been removed from the top of the 20-inch casing, the 20-inch and the 30-inch casing are cut either with a cutting tool or with a circular charge of dynamite (after having obtained permission from the authorities) about 3 m below the seabed. The severed casing together with the permanent guide base is then lifted and disposed of in an onshore waste disposal site, leaving the seafloor clear of obstructions. Side-scan sonar images of properly abandoned drill sites show only a shallow depression.

The technology for the removal of wellheads only became available after 1983. Prior to that time it was international practice to leave the permanent guide base with its 4,6 m high guideposts on the seafloor when a well was abandoned.

5.6 The drilling mud

The drilling mud is one of the most critical components of the whole drilling operation and it performs the following important functions:

- provides hydraulic power to the drill bit;

- cools and lubricates the bit;
- blocks off pore spaces in permeable rocks formations with a thin layer of filter cake (clay) thereby preventing loss of drilling mud;
- helps to support the weight of the drillstring through buoyancy (a 4 km long drillstring weighs up to 120 tons);
- transports the well cuttings to surface;
- exerts a hydrostatic head of pressure when properly weighted with dense additives which prevents the hole from collapsing, prevents high-pressure fluids from flowing into the well bore and prevents blow outs;
- is viscous enough to prevent settling of cuttings when drilling is temporarily stopped;
- acts as the lubricant for drilling.

The water-based drilling mud is usually a mixture of sea water, KCl, clay, barite and an organic polymer. Often lignin and lignosulphonates are used to help control the pH of the mud and prevent flocculation of the clay. The clay is normally bentonite, an inert, commonly occurring clay onshore. This acts as a gelling or thickening agent and forms the filter cake on the walls of the wellbore if the drilling mud is being lost into a porous formation. Barite, (BaSO4), is for weight and the amount of barite added increases with increasing depth of the well since the rock pore pressure also increases with depth. Barite is inert but may contain very small amounts of heavy metals in the form of insoluble sulphides. Such insoluble heavy metal sulphides are always a naturally occurring component of sea-floor sediments and reach their highest concentrations in areas of high organic deposition such as along the Namibian coast. Polymers form swollen gels in low concentrations and are used to thicken the mud, stabilise the clay and flocculate drilled solids. They also serve as emulsifiers and lubricants. In the United States, four compounds make up 90% of the additives to sea water in a drilling mud, namely barite, bentonite, lignite and lignosulphonate (Hinwood *et al.*, 1994). Although all muds use the same basic components, each well has its own unique problems and components are added or mixed in different proportions to overcome these problems. Therefore, no two muds are identical.

Common additives to sea water in water-based drilling muds are (from Hinwood *et al.*, 1994):

Weighting agents:	Barite ($BaSO_4$), ($CaCO_3$ and haematite not used in Namibia);
Gelling agents:	Bentonite, attapulgite (clays)
Alkaline chemicals:	NaOH, $Ca(OH)_2$, KOH.
Salinity chemicals:	NaCl, KCI, $MgCl_2$,' $CaCl_2$,' gypsum, $NaNO_3$ NH_4NO_3.
Lost circulation material:	Nut shells, vegetable fibre, $CaCO_3$, mica flakes, shredded cellophane.
Polymers:	Starch, starch derivatives, guar gum, xanthum gum, carboxymethylcellulose (CMC), hydroxyethylcellulose (HEC), polyanionic cellulose (PAC), partially hydrolysed polyacrylamide (PHPA).
Acrylic polymers:	Various polymers and co-polymers produced from acrylonitrile.
Asphalt products:	Asphaltines and resins, Gilsonite.
Defoamers:	Alkyl phosphates, aluminium stearate.

Biocides: Glutaraldehyde, paraformaldehyde.

Corrosion inhibitors: Organic corrosion inhibitors, oxygen scavengers, sulphide scavengers (Fe_3O_4, $ZnCO_3$, $Zn(OH)_2$, ZnO B used where H_2S is expected).

Scale inhibitors: Phosphate esters, phosphonates, polymers, phosphoric acid, HCl.

Drilling lubricants: Glass beads, teflon beads, diesel oils, triglycerides, fatty acids

Pipe release agents: Various products generally containing high detergency chemicals such as sulphonates, modified asphaltics and fatty acid salts, in combination with a hydrocarbon based external phase.

5.7 Cement

The 30-inch and 20-inch casings are cemented into the well bore over their full length. Various compounds are added to the cement to control it properties. These serve to:

- increase or decrease the density of the cement slurry;
- change its rheology (flow properties);
- increase the compressive strength of the set cement;
- increase or reduce the setting time;
- prevent fluid loss.

Additives and their functions are:

Accelerators: Inorganic salts ($CaCl_2$, NaCl), gypsum, sodium silicate

Retarders: Lignins, calcium lignosulphonate, carboxymethyl/hydroxyethyl cellulose, high concentrations of NaCl (above 10 per cent)

Density control: Bentonite, nitrogen, diatomaceous earth, expanded perlite, barite, silica flour, haematite, ilmenite

Defoamers: Alkyl phosphate esters, modified fatty acids, polyoxylated alcohols

Spacers: Alkyl glycol ethers, surfactants.

CHAPTER 6:

ENVIRONMENTAL ASPECTS OF DRILLING

Contents

6. ENVIRONMENTAL ASPECTS OF DRILLING 6.1
6.1 Introduction 6.1
6.2 Cuttings 6.1
6.3 Drilling mud 6.2
6.4 Other discharges into the sea 6.4
6.5 Solid waste 6.6
6.6 Atmospheric emissions 6.7

Tables

Table 6.1: Common components in water-based drilling mud 6.3

6. ENVIRONMENTAL ASPECTS OF DRILLING

6.1 Introduction

The results of the EIAs, which are a legal requirement in Angola and Namibia, are incorporated into drilling management plans to ensure proper implementation of the mitigation measures outlined in the EIAs. In South Africa and environmental management programme report (EMPR) is a legal requirement. An EIA is an integral component of an EMPR.

During drilling, cuttings and some water-based drilling mud are discharged overboard. Various types of waste are generated and specifically treated. There are also some emissions to the air. The manner in which each of these is reported on in the EIAs and handled in terms of the management plans is presented below.

6.2 Cuttings

The discharge of cuttings overboard has two immediate effects on the environment. Firstly, a broad but shallow mound of cuttings accumulates adjacent to and down current of the well and has a smothering effect on the benthos. Secondly, a plume of fine particulate material (“fines”) clouds the water down-current of the rig for a few hundred metres.

The cuttings are simply chips of rock and sediment that the bit drills through. They range in size from a powder to rock chips up to 4 mm in diameter. The cuttings are carried up to the rig by the circulating drilling mud. On the rig, the drilling mud carrying the cuttings is fed onto the shale shakers where the cuttings and mud are separated from each other. The mud is recovered, reconditioned and returned to the mud tanks ready for drilling. A small proportion of the cuttings is kept for analysis and study and the rest is discharged overboard about 10 m below the sea surface. In the Benguela Current region this has always been the practice for wells drilled with water-based muds since this is the accepted international practice even in countries such as Norway with important fishing industries.

Many studies have been carried out on the effect on the environment of discharging cuttings overboard. With exploration wells, the effects are minimal since cuttings from only one well at any one locality are involved. It is different with production platforms where up to 100 wells may be drilled in one locality from one such a platform.

COARSE CUTTINGS - The cuttings concentrate near the point of discharge and spread out over an oval-shaped area down-current of the rig. Ninety per cent of the cuttings accumulate within 100 m of the rig (Hinwood *et al.*, 1994) but they may occur up to 500 m away depending on the strength of the current. The mound of cuttings near the rig can be a metre or two high (Hinwood *et al.*, 1994) but the average thickness of cuttings from a 4 km-deep well such as that give in Table 5.1 would be 20 cm if they covered an area of 100 x 100 m. The cuttings, being from the underlying marine sedimentary rocks, are essentially non-toxic. Those from oil-bearing rocks, however, would be toxic and should be brought ashore for land-based disposal in the same way that cuttings from wells drilled with oil-based drilling muds are. In the relatively quieter bottom water environments in which the Angolan and Namibian wells have been drilled, dispersal distances of about 150 m might be expected, similar to that for low-energy environments in the North Sea (Ray and Meek, 1980; Ayers, *et al*., 1980). In such low-energy environments, benthic populations 150 to 200 m from the rig quickly return to normal and beyond 500 m no changes in the benthic populations have been recorded (Ranger, 1993). Recovery of the impacted area is thought to be rapid (Ferbrache, 1983). Bioturbation plays an important role in the recovery of the sea bed (Coates, 1994).

FINE CUTTINGS - The plume of fines in the upper part of the water column contains about 5-7% of the total solids discharged (Ayer *et al*., 1980a & b; Hinwood *et al*., 1994). Within 100 m, the suspended sediment concentrations will have fallen by a factor of at least 50 000 (Hinwood *et al*., 1994). Since these fines include the fine material from the drilling mud, the effect of the fine cuttings will be considered in conjunction with the fines from the drilling mud.

6.3 Drilling mud

Approximately 10% of the drilling mud is discharged overboard with the drill cuttings Neff *et al*., 1987). As the bulk of the mud remains in the well when it is plugged and abandoned, the total amount of mud discharged during the drilling of an average well is approximately 750 barrels (107 m^3: 1 barrel = 143 litres) (Chevron, 1994). Table 6.1 indicates the toxicity of the more common additives in drilling muds used in Namibia and South Africa. H_2S is not expected in the potential hydrocarbon-bearing formations in Namibia and South Africa so zinc-bearing sulphide scavenger additives have not been used to date. In Angola, where H_2S is encountered, such additives are used.

The bulk of the barite in the discharged drilling mud, being heavy, settles with the coarse cuttings. The fine-grained, light-weight components in the drilling mud and the fine, powdered cuttings form the plume of fines in the upper water column. A typical plume is 30-40 m in vertical height, 40-60 m wide and generally between 100 m to 4 km long (Gettleson *et al*., 1980) although some plumes have been followed visually from the air for up to 17 km (Hinwood *et al*., 1994).

Table 6.1: Common components in water-based drilling mud (from Chevron, 1994; Hinwood et al., 1994).

COMPONENT	USE	ECOTOXICITY	APPROXIMATE CONCENTRATION (WEIGHT % OR PPM)
Barite	Weighting agent	Chemically inert 96 hr LC (50)* >100%	20 - 25
Bentonite	Viscosifier, lubricant	Chemically inert 96 hr LC (50)* >100%	2
Caustic soda	pH elevator, calcium reducer	Soluble, corrosive	0.06% or 600 ppm
Lignite,	Deflocculant, viscosifier, lost circulation and filtration control, thermal stabiliser, calcium reducer	Insoluble, non toxic 96 hr LC (50)* >100%	400 - 8500 ppm
Lignosulphonates	Deflocculants, anti corrosion agents	Soluble, some slightly toxic, 96 hr LC (50)* > 1000 ppm to >100%	25 B 1200 ppm
Sodium bicarbonate	Calcium buildup reducer	Soluble, non-toxic	
Gypsum	Calcium source for certain mud types	Slightly soluble, non-toxic, 96 hr LC (50)* >100%	
Cellulose-based polymers	Lost circulation control	Insoluble, non-toxic 96 hr LC (50)* 47->100%	
Synthetic and natural organic polymers	Gelling agents, clay stabilisers, lubricants	Some slightly toxic, 96 hr LC (50)* > 500 ppm B >100%	40-2000 ppm
Gilsonite (heavy molecule asphalt)	Lubricant, lost circulation control	Slightly soluble, non-toxic	
Aluminium stearate	Lubricant, defoamer	Insoluble, non-toxic 96 hr LC (50)* >100%	300 ppm
Paraformaldehyde	Bactericide	Toxic (Biocide - 96 hr LC (50)* > 45%)	Up to 1000 ppm

* *The concentration at which 50% of a test population (often shrimps) is killed within 96 hours*

Dilution of the discharge already starts in the discharge pipe. One study showed the dilution of the plume of fines from the mud and cuttings to be 10 000 times within 100 m of the rig in currents as low as 0.05 m/s with only slight wave action (Haughton *et al*., 1980). Thus, a 0.1% solution (1000 ppm) of the bactericide paraformaldehyde in the mud (used to prevent biodegradation of the organic polymers in the mud) is diluted to 0.00001% within 100 m of the point of discharge. Studies by Ayers *et al*. (1980a & b) who measured suspended sediment concentration, light transmission, dissolved oxygen, pH, temperature, salinity and the concentrations of some metals showed that solids concentration fell by factors of 3 000 to 5 000 within 5 m of the well and by 50 000 within 100 m. Clays flocculate and settle out (Hinwood *et al*., 1994). The toxic effect of sodium hydroxide will be due to increased pH but concentrations in the drilling fluid are already low and any effect would be of very short duration due to the rapid dilution by sea water. Organic compounds undergo biogenic degradation. The plume travels further than the material deposited on the seabed. Its greatest effects are on nektonic and planktonic species through reduction of light penetration and clogging of filter feeders. However, dilution is so rapid that chemical and physical effects will be minimal. The above studies showed that all measured variables except suspended sediment and light transmission had returned to background levels within 100 m. Suspended sediment returned to background levels within 300 to 500 m and light transmission within 600 to 1 000 m, even when plumes were visible from the air for several kilometres.

In Namibia and South Africa, mean current speeds are 15 cm/sec but the sea state is often rough with swells below 2 m being very rarely recorded so that plumes will be rapidly dispersed and are not likely to be of great length. In Angolan waters which generally have moderate sea state conditions the plumes may be more persistent and extend for greater distances.

6.4 Other discharges into the sea

CEMENT

About 5% (25 tons) of the total amount of cement used to cement the 30-inch and 20-inch casings in place oozes out of the top of the well bore onto the sea floor. Most of the cement which oozes out from the well bore is dispersed by currents before it has time to set. The additives listed are used extensively in the North Sea and have a low toxicity to marine life (Ranger, 1993; Chevron, 1994). The organic additives are partially biodegradable. The cement on the sea floor is not recovered since the impact on marine life is negligible.

CLEAN-WATER DRAINAGE

This is rain water and non-oily wash-down water and is discharged directly overboard.

OILY WATER DRAINAGE

This is generally oily water from work areas, generator rooms, machinery rooms and diesel storage areas. Although South Africa is the only Benguela Current signatory of MARPOL 73/78 (International Convention for the Prevention of Pollution from Ships, 1973; modified by the Protocol of 1978), any ship or rig flying the flag of a party to the Convention must comply with MARPOL 73/78 requirements. Thus, oily water must contain less than 15 ppm oil before being discharged overboard. Generally, the oily water is treated in an oil/water setarator. Separated oil is stored in holding tanks for later onshore disposal.

DRILLING AREA DRAINAGE

These are fluids from the drill floor (drilling mud), mud pit rooms, mud pump room and solids control areas as well as the wash-down water for these areas. All these fluids are derived from the mud system which, being water-based, are discharged overboard.

BOP HYDRAULIC FLUID

During the routine but essential testing of all the working parts of the BOP, approximately 12 000 litres of oil-based hydraulic fluid vents into the ocean at the seabed. Concentrated BOP fluids are mildly toxic to crustaceans and algae (96 hr LC (50) 102-117 ppm) but these fluids are diluted 1:50-100 with fresh water in the BOP. They completely biodegrade within 28 days (Chevron, 1994). Their application is absolutely essential for safety reasons. The effect of a major oil spill is infinitely more serious than the impact of the hydraulic fluid discharged to ensure safe operation of the well.

SEWAGE

This follows the MARPOL Annex VI requirements that apply to ships. Sewage is comminuted and disinfected so that it neither produces floating solids nor causes discolouration of the water. Treatment systems generally provide primary settling, chlorination and dechlorination. Disposal is about 10 m below surface. For a 75-day operation with 80 people on a rig, the sewage system will be required to handle 204 litres/person/day or a total of 1.2 million litres (Chevron, 1994). Chevron's limits for treated sewage are:- 150 mg/l suspended solids, less than 200 faecal coliforms per 100 ml, and 1 mg/l residual chlorine (Chevron, 1994).

The primary environmental effect of sewage will be an increase in the micro-nutrients nitrogen and phosphorus and reduction in the oxygen content of the sea water close to the rid due to biogenic decay. The micro-nutrients normally result in enhanced biological productivity in the receiving water but, as with the drilling plume, dilution is so rapid the local effects are very limited, organic enrichment is insignificant and of very limited duration. Concentrations of nutrients fall rapidly to background levels.

FOOD AND GALLEY WASTE

This is macerated and discharged overboard. It will have a similar local effect on the environment as the sewage.

DETERGENTS

Water-soluble detergents are generally used which rapidly become highly diluted when discharged overboard (Boesch *et al.*, 1987). Detergents used in deck spaces are collected and treated with the oily water drainage.

SEA WATER

Sea water is used for the drilling mud, for cooling (mainly the diesel engines), for the fire and wash-down systems and for distillation to produce potable water. Biocides and corrosion inhibitors are occasionally included in the cooling water and potable water system to protect equipment. This sea water is discharged overboard if it has not become contaminated.

6.5 Solid waste

Solid waste brought ashore for disposal on land. For all the Namibian wells drilled to date, material destined for landfill disposal has used the Walvis Bay municipal landfill, authorisation therefor having first been obtained. In South Africa, solid waste is taken to the nearest suitable officially-certified disposal site. In Angola the situation is more problematic since current circumstances prevent the proper operation of disposal sites.

RUBBISH AND TRASH

Rubbish and trash includes paper, plastics, metal, glass etc from the rig, onshore offices and accommodation and contracting warehouses and is calculated at 3.3 m3/person/year and 66 m3/well (Chevron, 1994). Non-toxic, combustible material is burnt on the rig but the rest is disposed of in landfills ashore.

LUMBER, PACKAGING MATERIALS AND TYRES

Non-toxic, combustible material may be burnt on the rig or onshore. Plastics and tyres are disposed of in landfills. Several cubic metres per well are produced.

SCRAP METAL

Scrap metal is disposed of either in a landfill or on contract to a scrap metal dealer depending on the nature of the scrap. Several cubic metres per well.

DRUMS AND CONTAINERS

Drums and containers that contained toxic or potentially toxic material are rinsed either on board or ashore. Rinsing water is disposed of in a manner acceptable to the local authorities. All drums are then crushed to reduce volume and disposed of in a landfill. About 25 drums per well are produced.

CHEMICALS AND HAZARDOUS WASTES

A register is kept of all hazardous chemicals and materials taken aboard and used. These have all been dealt with in different sections of this report but any unexpected chemicals are handled on a case-by-case basis.

LABORATORY WASTES

Minor quantities of laboratory waste are generated during water quality analysis and retort analysis. These are dealt with according to the requirements of the local onshore authorities.

INFECTIOUS WASTE

Infectious wastes are mainly from the sick bay on board. They are properly isolated and are disposed of in accordance with the operator's health, safety and environment procedures and, where appropriate, close coordination with the medical authorities on shore. Syringes are destroyed.

FILTERS AND FILTER MEDIA

Filters and filter media from air, oil and water filters used in onboard machinery are disposed of in landfills after having consulted with the local authorities.

6.6 Atmospheric emissions

Atmospheric emissions include the exhaust gases from generators and other fuel-burning machinery, the gases from burning of hydrocarbons during well testing as well as the burning of combustible waste. MARPOL standards for atmospheric emissions (Annex VI) have been established but have not been adopted by any of the Benguela Current countries.

MACHINERY EXHAUST GASES

An average drilling rig consumes about 75 barrels/day (10 725 litres) of diesel fuel. Resulting volumes of exhaust gases vented to the atmosphere are:

CO_2 = 32 B 45 tonnes/day
NO_x = 0.25 - 0.6 tons/day
CO = 0.015 B 0.14 tons/day
Particulates = 3 kg/day (Ranger, 1993; Chevron, 1994).

WELL TESTING

Testing of a well typically will last between 3 and 5 days during which time the gas is flowed several times for a few hours to the surface and burnt (flared) in a high-efficiency burner located at the end of a boom suspended over the water. Total flow time may amount to two days in total. In the case of the Kudu discovery in Namibia, the gas consists of almost pure methane, some nitrogen and very minor heavier hydrocarbons. Combustion products from a high efficiency burner will therefore be almost pure CO_2 and water vapour, H_2O, with small amounts of NO_x and CO. When H_2S is present, such as in Angola, So_x will be produced by flaring of gas. Methane has an SG of 0.5537, two days of flowing and burning the gas at a rate of 1 100 cubic metres (40 million cubic feet) of gas per day will produce about 3 400 tons of CO_2.

Studies in the North Sea have shown that the daily quantities of NOx, SOx, CO, and unburnt methane and hydrocarbons produced from flaring of gas during oil production (much lower than the volumes of gas flared at Kudu) are very low and air quality downwind of the production platforms corresponded to "a non-industrialised, rural environment" (Ranger, 1993).

COMBUSTIBLE WASTE

The non-toxic, combustible waste burnt on the rig from time to time will create smoke but emissions are minor.

CHAPTER 7:

OIL SPILLS AND CONTINGENCY PLANS

Contents

7. OIL SPILLS AND CONTINGENCY PLANS 7.1

7.1 Contingency plans 7.1

7.2 Oil Spills 7.9

Figures

Figure 7.1: Structure of the Government Action Control Group (GACG), Namibia 7.3

Figure 7.2: IKU and NAMCOR drifter buoy tracks off the northern coast of Namibia (from CSIR, 1995)... 7.12

Figure 7.3: Composite of all drifter buoy tracks (from Gründlingh, 1999) 7.13

Figure 7.4: Partial tracks of drifter buoys released in October 1994 showing the effect of two shelf waves CTW1 and CTW2 (from CSIR, 1995) 7.14

Figure 7.5: Tracks of drifter buoys deployed in December 1994 (from CSIR, 1995) 7.15

Figure 7.6: Track of drifter buoy # 22982 deployed during February 1995 (from CSIR, 1995) 7.16

7. OIL SPILLS AND CONTINGENCY PLANS

7.1 Contingency plans

ANGOLA

The Petroleum Ministry (MINPET) has engaged the assistance of the International Maritime Organization (IMO) and the International Petroleum Industry Environmental Conservation Association (IPIECA) in the formulation of a National Contingency Plan for the Prevention and Management of Oil Spills. The companies comprising the Angolan oil exploration and production industry are providing assistance with the formulation of the oil spill contingency plan.

The Petroleum Ministry has the overall responsibility for the formulation and implementation of the oil spill contingency plan. The Minister of Petroleum presides over the National Oil Pollution Committee on which five other ministries are represented:

- Ministry of Defence
- Ministry of the Interior
- Ministry of Transport
- Ministry of Fisheries and the Environment
- Ministry of Finance.

These ministries form the nucleus of the National Oil Pollution Commission. Other government institutions, NGOs and other interested parties are consulted by the Commission whenever necessary.

A Technical Committee, whose members are drawn from MINPET and from the Angolan petroleum industry, provides the technical input to the National Oil Pollution Commission. For example, the Technical Committee assists with the formulation of strategic and operational plans to deal with oil spills. The Strategic Plan provides a national framework for responding to oil spills whereas the Operational Plan covers the actual operational procedures. These operational procedures include reporting of spills, response procedures, clean-up methods, etc.

A Data Base will be established containing coastal sensitivity maps, inventories of equipment, contact information for key response personnel, information on dispersants, etc.

At the time of writing the national oil spill contingency plan/system is not fully operational. Individual oil exploration and production companies establish their own procedures for the combating of oil spills and will co-operate with each other in the event of a major spill.

Texaco Inc., Angola has undertaken an evaluation of aerial video photography with GPS indexing to provide rapidly accessible information on the coastline for utilization by oil spill response crews. Continuous vertical and oblique coverage of the coast between Luanda and Lobito has been obtained.

NAMIBIA

In Namibia, the licensee is fully responsible for ensuring that each well is drilled with maximum efficiency, in the safest possible manner and with the least danger to personnel and the environment. The licensee carries the full responsibility for any accident and any pollution that occurs must be cleaned up to the full satisfaction of the authorities. Thus, each well is preceded by the preparation of four well management plans, namely the Contingency Plan, the Safety, Environment and Health Plan, the Waste Management Plan and the Oil-Spill Contingency Plan. All the mitigation measures from the EIA are built into these plans. The licensee appoints an emergency team consisting of both rig- and office-based personnel. To ensure familiarity with emergency procedures, all the licensee's personnel as well as its own head-office emergency team and those of the contractors on the rig and on the standby boats are all required to familiarise themselves with emergency procedures as detailed in the contingency plans. At least one emergency exercise is held about a week before arrival of a rig in Namibian waters. It is a standard procedure to have regular safety discussions and even exercises on a rig in order to heighten the awareness of the crew.

Once a rig is selected but several months before drilling is due to commence, the licensee inspects the rig and its equipment in detail to ensure that safety standards are complied with and that all equipment is functioning properly and according to specification. Any shortcomings must be rectified before the rig anchors to drill the licensee's well. In almost every case, the Ministry of Mines and Energy contracts rig licensing companies such as DNV to inspect the rig on its behalf once it has reached Namibian waters. In this way rigs have been subjected to at least two inspections before or at the commencement of drilling.

The location of the rig is relayed to all shipping by means of a notice to mariners issued by NAMPORT and the South African Navy in Cape Town. A 500 m-wide "safety zone" from the centre of the installation as specified in the UN Law of the Sea is declared. Within the zone no fishing, no anchoring and no unauthorised overflying is permitted. The Notice to Mariners should include the 500 m safety zone as well as a warning note to fishing vessels to "keep well clear" since anchors are laid around the installation at distances of up to 1 700 m in water depths of 100 m. The anchor spread will be far greater in deeper water. The anchors are not marked with buoys.

According to world exploration drilling records, the chance of an oil spill occurring during exploration drilling is less than about 1:8000 (pers. com., Norsk Hydro, 1997). Nevertheless all licensees contracted the Oil Spill Response Centre (OSRC) in Southampton to be on standby during the drilling of their Namibian wells. The OSRC has a large stock or marine oil spill combating equipment which could be airlifted to Walvis Bay within 36 B 48 hours. The OSRC staff have experience in combating spills.

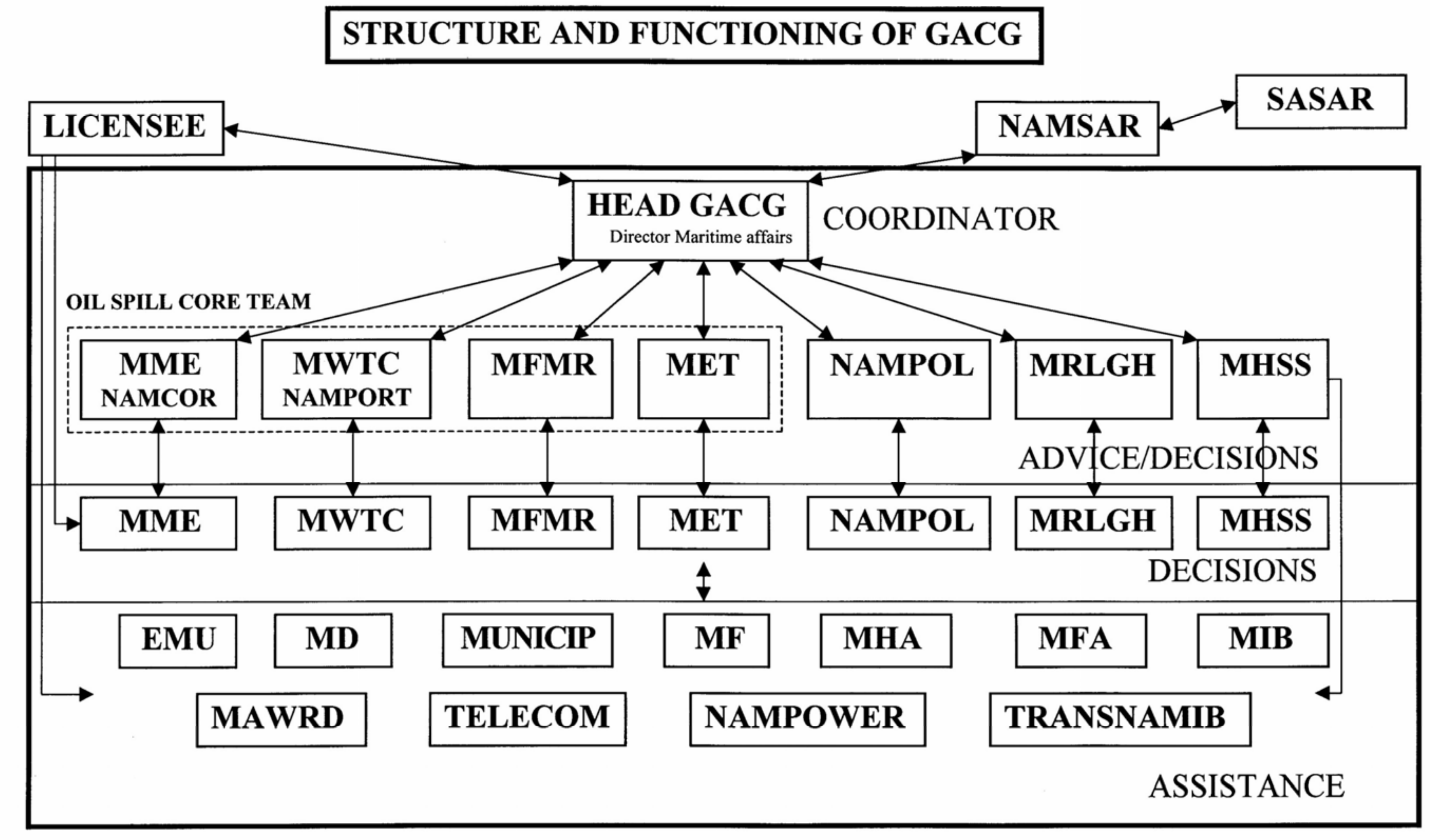

Figure 7.1: ***Structure of the Government Action Control Group (GACG), Namibia***

THE GOVERNMENT ACTION CONTROL GROUP (GACG)

Since emergencies can involve other companies, the government and other countries, it was considered necessary in the interests of speed and efficiency in an emergency to develop a government offshore emergency team capable of providing support to the licensee or even management of an offshore emergency involving either people or oil spills. NAMCOR, with extensive and willing assistance from the Norwegian State Pollution Control Authority and the licensees, was instrumental in initiating and commissioning development of the Government Oil Spill Contingency Plan, in identifying the key ministries whose representative would serve as the core emergency team as well as those ministries whose support might be needed in an emergency (Miller, 1998). Workshops, training programmes and exercises were arranged for the core team, for the other support ministries and for a large number of government, parastatal, municipal and upstream and downstream oil company personnel in Windhoek and at the coast. This training included explaining the behaviour of oil on water, the limitations of oil spill clean up, the limitations of equipment and the do's and don'ts in oil spill emergencies. Key personnel were flown to Europe and Scandinavia to inspect facilities and organisations and to observe various types of exercises.

The GACG falls under the Emergency Management Unit (EMU) of the Office of the Prime Minister. The EMU reports to an emergency committee comprising the Permanent Secretaries from all ministries. The head of this committee is the Secretary to the Cabinet.

The structure of the GACG is outlined in Figure 7.1. It consists of two core components, as search and rescue component and an oil spill component. The GACG is headed by the head of Namibia Search and Rescue (NAMSAR). The head will handle any search and rescue situation but will delegate the running of an oil spill combating operation to the oil spill section. The core team of the GACG consists of representatives from the following ministries and parastatals:

Ministry of Works Transport and Communication, Directorate of Civil Aviation (and head of GACG) and Directorate of Maritime Affairs;
Namibian Ports Authority (NAMPORT);
Ministry of Mines and Energy;
National Petroleum Corporation of Namibia (NAMCOR) B coordinator of GACG and head of oil spill component;
Ministry of Fisheries and Marine Resources;
Ministry of Environment and Tourism;
Namibian Police;
Ministry of Regional and Local Government and Housing;
Ministry of Health and Social Services.

Almost all other ministries have nominated representatives on standby to assist the GACG in their specialised field should this assistance become necessary, e.g. with rapid customs clearance for specialised equipment, visas for personnel to man the specialised equipment, coordination with neighbouring countries and governments, manpower deployment for clean up operations etc.

The South African Search and Rescue (SASAR) organisation is internationally responsible for search and rescue in the whole Southern African region from the Kunene River to South Africa's border with Mozambique and from 10°W to 75°E and south to the South Pole. Thus NAMSAR can call on SASAR directly to assist in a search and rescue operations or to stand by in case its assistance may be needed. At the least, NAMSAR must inform SASAR of a search and rescue operation.

Ministerial and parastatal representatives serving in the core component of the GACG have attended many of the licensee emergency exercises and on occasion have been drawn extensively into the exercise to test the GACG's ability to cope with providing assistance.

NAMSAR can be alerted through an on-duty air traffic controller at any airport in Namibia. NAMSAR is fairly experienced in its field since it has been called up on several occasions to search for missing aircraft. The oil spill component of the GACG does not have the same level of experience since it has rarely been called out. It is therefore understandable that not all its members are on the same level of continuous alertness as NAMSAR. However, the GACG alerting point for oil spills, the NAMPORT control room, is manned 24 hours a day and is thus as fully alert as any manned air traffic control tower. Nevertheless, when a rig anchors, NAMCOR informs all members of the GACG and put them on the alert until the rig completes drilling.

National Oil Spill Contingency Plan

The National Oil Spill Contingency Plan (NOSCP), which guides the GACG during an emergency, lists 17 types of emergencies. For each emergency there is a list of the ministries to be called out and/or informed. The manual also contains all the contact numbers of all ministerial, parastatal and municipal representatives serving on the GACG as well as their alternate nominees who are required to have undergone the same training as the main nominees. Since staff changes take place on a regular basis, it is necessary to update the nominee list and contact numbers at least once a year. For the same reason training and exercises should be repeated on a regular basis to train new nominees and to refresh the abilities of existing nominees.

A report on Namibian coastal environment (O'Toole, 1993) forms an annexure to the NOSCP. This report was the outcome of a workshop attended by many people from several ministries, coastal municipalities and members of the public. It points out particularly sensitive and vulnerable areas and gives site-specific instructions for the action to be taken along each section of the coast if an oil spill were to come ashore. It also includes guidelines on how to handle various situations arising from coastal oil pollution.

At present in the Ministry of Works, Transport and Communication is revising and updating the NOSCP since the legal responsibility of the combating of marine oil pollution in Namibian waters falls under that ministry. The Directorate of Maritime Affairs will then take over the leadership role of the present GACG as far as oil spills are concerned. Search and Rescue will still remain under the leadership of NAMSAR which falls within the Directorate of Civil Aviation in the same ministry.

Dispersants

Since the toxic components of oil are largely those that readily evaporate, there is a general reluctance to use dispersant since this must be used at an early stage in a spill and certainly before all the volatile components have evaporated. There has been general agreement at various workshops in Namibia not to use dispersant unless a key shore-based seabird or seal colony is under immediate threat from the oil. Even then dispersant would be a last resort. It has also been agreed to follow the South African practice of not using dispersant in water less than 35 m deep. The dispersant recommended by the GACG is OSE-750 because of its low level of toxicity and its local availability (from Drizit in Durban). Dispersant may only be used after approval from the Ministry of Fisheries and Marine Resources.

Oil spill combating equipment available in Namibia

The only equipment in Namibia is that owned by NAMPORT and this is only specified for use in sheltered bays, not the open ocean. At Walvis Bay this consists of:

- 200 m Seaserpent inflatable boom, FB = 470 mm with 2 air inflators, towing bridles, towing ropes; for use in bay;
- 75 m of Vikoma Sea Guardian inflatable booms with air inflator; for use in port;
- One Walosep weir skimmer with hydraulic diesel power pack. Hydraulic mono pump, capacity 90m^3/hr. Discharge hoses, hydraulic lines, spares; for use from ship;
- One Vikoma Komaro K12 disc skimmer, trolley-mounted, diesel-driven power pack, pump + diesel engine, discharge, suction and hydraulic hoses, spares;
- One Foilex weir skimmer with diesel-driven power pack, hose reel, hydraulic hoses, discharge hose, floats, spares, for use from ship;
- One Foilex off-loading pump for highly viscous liquid, 130 ton/hr;
- 240 m Oilstop inflatable boom, trolley-mounted, petrol-driven inflator.
- Stock of sorbant B Drizit loose fibres, cushions, micro booms; Spilsorb pillows.

Equipment at Lüderitz consists of:

- 3x 100 m expandi self-inflating boom for sheltered waters, towing bridles and ropes;
- One Vikoma Komaro disc skimmer, trolley-mounted, diesel-driven hydraulic power pack, hoses, spares.
- Stock of sorbant B Drizit loose fibres, cushions, micro booms.

SOUTH AFRICA

South Africa has drawn up a comprehensive set of oil spill contingency plans for dealing with oil spills at sea and those that foul the coastline.

In terms of the Marine Pollution (Control and Civil Liability) Act 6 of 1981, the Department of Transport is charged with the responsibility of ensuring that the appropriate actions are taken in order to minimise the impact of discharges of oil from ships, tankers or offshore installations. In terms of the South African Maritime Safety Authority Act 5 of 1998, the majority of these responsibilities are transferred to the South African Maritime Safety Authority (SAMSA). Section 52 of the SAMSA Act, however, delegates the responsibility for combatting pollution of the sea and shoreline by oil to the Minister of Environmental Affairs & Tourism. The implication of this is that the Department of Environmental Affairs and Tourism (DEAT&T) is responsible for protection and clean-up measures to be taken once oil has been released to the sea whereas SAMSA's responsibility is limited to actions required while the oil is within the confines of the ship. In effect this means that SAMSA is responsible for:

- the control of shipping casualties
- the supervision of oil transhipments
- initiating prosecutions resulting from deliberate discharges of oil to sea
- the legal aspects pertaining to a shipping casualty or oil spill, for example negotiation with owners and insurers
- the processing and payment of claims relating to an oil spill,

while the Department of Environmental Affairs and Tourism is responsible for:

- the co-ordination and implementation of coastal protection and clean-up measures during an oil spill incident
- the control of Kuswag vessels and aircraft
- the control of all dispersant spraying operations
- the maintenance of dedicated oil spill equipment and dispersant stocks held by the Department
- the compilation of Local Coastal Oil Spill Contingency Plans.

In order to structure the actions to be taken in the event of an oil spill, various plans have been compiled, each dealing with a particular aspect of the spill situation. Although each of the following plans is referred to as a plan, each should be read in conjunction with the others, as the composite Oil Spill Contingency Plan.

- Master Plan
- Plan for Control of Shipping Casualties
- Plan for Combating Oil Spilled at Sea
- Plans for Independent Installations
- Local Coastal Plans.

The *Master Plan* is an overall plan setting out the policies of the Department of Environmental Affairs and Tourism and the Department of Transport towards their responsibilities in preventing and combatting pollution of the sea by oil. It provides an overview of the actions to be taken by SAMSA, DEA&T and other relevant authorities in preparation for, and in the event or the threat of an oil spill, and inter-relates these activities with those described in the other plans.

The *Plan for Control of Shipping Casualties* sets out the requirements of the Department of Transport with respect to any contemplated salvage. Actions being taken in terms of this plan may affect those being taken in terms of the Local Coastal Plans.

The *Plan for Combatting Oil Spilled* at Sea details the response actions that are to be taken at sea by the Department of Environmental Affairs and Tourism and inter-relates them to those being taken in terms of the Local Coastal Plans.

The *Plans for Independent Installations* detail the response actions that are to be undertaken in the event of an oil spill at or near a specific installation. These installations include offshore oil tanker discharge facilities, oil exploration and exploitation sites, power stations and ports, harbours and yacht basins.

The *Local Coastal Plans* detail the actions to be taken when there is a threat of oil impacting the shoreline or an impact has occurred. The coastline from the Orange River mouth to the Mozambique border has been divided into 25 zones, each of which has its own specific Local Coastal Plan. These Local Coastal Plans are used in conjunction with the information contained in the *Coastal Sensitivity Atlas of Southern Africa* (Jackson and Lipschitz, 1984). The atlas depicts the nature of the shoreline (sandy beaches, rocky shores, wave-cut platforms, etc.), estuaries, conservation areas, seabird and seal colonies, industrial and domestic effluent outfalls, power station intakes, and oil discharge facilities (single point moorings).

The oil spill contingency plans for each zone set out the respective responsibilities of the Department of Transport (DOT) and the Department of Environmental Affairs and Tourism relating to an oil spill, the organisation that will be established and the actions required of local authorities and other bodies to combat the effects of oil pollution on the shoreline in the event of an oil spill at sea.

The primary objective of the oil spill plans is to minimise loss of time and hence, environmental damage, in carrying out the appropriate remedial action. This is achieved by stating clearly the functions and responsibilities of the various bodies involved, the infrastructure to be set up, and the response required by such bodies for the duration of the incident.

Dispersants

South Africa, through the Department of Environmental Affairs and Tourisms (DEA&T), has established a policy, also adopted by Namibia, on the use of oil spill dispersants.

Oil spill dispersants have frequently been used during response operations. Their use, however, is controversial, as it has both advantages and disadvantage. Disadvantages include the fact that application of dispersants results in increased concentrations of oil in the water column, and that oil/dispersant mixtures are generally more toxic than the oil itself. Moreover, dispersants are only effective on certain types of oil, and even then, only within a limited time span after the spill. It is very important, therefore, that their use is properly controlled; that they are used only when physical containment and removal is not possible, and that their use results in a net environmental benefit.

The key features of the South African policy on the use of dispersants are:

- Dispersants may only be used with authorisation by DEA&T.
- Dispersants should only be used in waters more than 5 nautical miles offshore and/or with a depth of more than 30 metres.
- Dispersants should only be used in circumstances where they are likely to prove effective.
- Dispersants should be applied preferably within 12 hours, or at a maximum, 24 hours after the oil's release.
- Dispersants should only be used where their use will result in a net environmental benefit. They should not be used in the following situations:

    (i) in areas of low water volume and a limited rate of exchange, e.g. bays, estuaries, etc.
    (ii) near shellfish resources
    (iii) in fresh water
    (iv) on established fish breeding grounds and in migratory areas
    (v) in the vicinity of industrial water intakes
    (vi) in areas far offshore where there is little likelihood of the oil coming ashore
    (vii) on the shoreline.

Emergency use of dispersants is permitted when:

(i) the slick is approaching islands/rocks supporting large seabird colonies, especially if these colonies include species that are rare or endangered.
(ii) the slick, although just beyond the 5 nautical mile offshore limit, is moving rapidly onshore (winds or currents onshore) into
    (a) an area with ecologically sensitive coastal features, e.g. estuaries or bays which it would not be possible to close artificially (e.g. Langebaan);
    (b) an area with important socio-economic features which could not be protected from impact, e.g. heavily utilised bathing beaches at the height of the holiday season.

7.2 Oil Spills

No significant spills have occurred during exploration drilling or production in South Africa and Angola and none at all in Namibia where, to date, only methane has been discovered. The risk of oil spills from petroleum exploration and production is much lower than that posed by shipping.

In all three countries oil spill simulations have been undertaken as integral components of EIAs. In most cases the American OILMAP model, developed by Applied Science Associates (ASA), has been used to perform both stochastic and trajectory and fate simulations.

To date the Namibian Government, through NAMCOR, is the only BCLME country to have invested into a study to improve the understanding of the trajectory and fate of oil spilled at sea.

NAMIBIA

Oil Spill Simulations

Oil drifts at 100% of the surface current speed and direction and 3.6% of the wind speed at an angle of -3° (i.e. 3° to the left) of the wind direction (Spaulding *et al*., 1991). The wells that have so far been drilled offshore Namibia are all 40 km or more from the coast. The oil spill drift simulations carried out by licensees were based on international wind and current databases as well as a large database at the CSIR in Stellenbosch. They showed the predominant drift direction would be NNW becoming NW as the oil reached locations more than about 100 km offshore. One of the simulations for Area 1911 (Norsk Hydro) showed oil potentially reaching the Kunene River mouth within six days. Another for Area 2815 (Chevron) showed oil potentially just touching the shore south of Lüderitz within 10 days. Others show the time it would take for oil to reach the shore if the predominant surface current moved directly or obliquely shorewards B only likely during strong northwesterly or southwesterly winds, west winds being rare and light. A major shortcoming of all the simulations was the fact that they all used average wind and current directions and did not model what would happen to the oil during northwesterly storms.

In an attempt to develop a better database and a better understanding of likely drift directions of an oil spill, NAMCOR undertook two drifter buoy studies offshore Namibia using buoys known to simulate oil drift reasonably well (IKU, 1994; CSIR, 1995). The IKU study released four buoys on 14 May 1993 at 21°10’ S at respective distances of 55, 88, 143, 201 km from the coast and tracked them for 30 days. All buoys drifted in an overall northwesterly direction (Figure 7.2). This trajectory was largely coast parallel up to 18oN. The buoy closest to shore (innermost) maintained a coast-parallel course up to the maritime border with Angola (i.e. it had a northerly course north of 18oN) but then veered off to the northwest. The average rate of drift of the innermost buoy was 32 cm/s for the 840 km straight-line distance travelled, that for the outermost buoy was 37 cm/s over 960 km. Apart from small excursions towards the coast for up to two days, this study showed that under the current and wind conditions prevailing at the time, any oil, even that within about 50 km of the shore would probably not reach the coast, would stay offshore and would in time drift even further offshore.

The second study was far more comprehensive and involved the release of eight buoys at bimonthly intervals from August 1994 to September 1995, four of Oranjemund at distances of 5, 15, 25 and 35 km from the coast and four off Swakopmund at the same distances from the coast. Figure 7.3 is a composite of all the trajectories. The overall trajectories for the southern group were northwesterly becoming WNW further offshore. Thus, for the most part, oil would remain offshore and with time would move even further offshore. However, closer inspection of individual trajectories reveals the effects of shelf waves of up to two days duration which moved the buoys shorewards (Figure 7.4). Some of the buoys released 5 km from shore landed up on the beach, some to the north, some to the south of the point of release. Others came very close to shore before finally moving offshore (Figure 7.4).

Shelf waves or coastal trapped waves (CTW) are forced by and travel with the coastal lows as they move southwards down the coast (Jury *et al*., 1990). The wind changes from southeasterly to northwesterly. Sea level reaches a maximum (10 B 50 cm) above the steady state level. The surface current reaches a maximum, is directed towards the southeast and therefore onshore and can reach speeds of up to 40 cm/s. The CTW may lag the passage of the coastal low by a day. CTW's are confined to the region within about 100 km of the coast. Thus, southerly to southeasterly drift will occur during the development of a coastal low and lasting as long as the coastal low lasts (normally one to three days) (CSIR, 1995). In the event of a nearshore oil spill it would help to predict its possible future drift direction by knowing whether a coastal low is in the process of developing.

In general, the northern group of buoys also drifted northwest, moving further offshore on a WNW trajectory with time (Figure 7.3). In some cases, all four buoys began to move further offshore from the onset (Figure 7.5) but for many of the releases, the two innermost buoys maintained a coast-parallel trajectory for at least 240 km before moving further offshore (Figure 7.2). Again some of the innermost buoys were driven ashore within a few days of release, either to the north or the south of the point of release.

Overall, most of the buoys diverged from the coast. Of 42 buoys that reached a distance of 50 km or more from the coast during the study, only one came ashore. Of 41 buoys that reached a distance of 25 km from the shore, again only one came ashore. Of 33 reaching 10 km from the coast, 6 (18%) came ashore. Of 15 deployed less than 10 km from the shore, 6 (40%) were washed ashore. There is thus a marked increase in the likelihood of oil reaching the shore if it is spilled within 10 km of the coast. Within 5 km of the coast, there is a 40% chance of it drifting ashore (CSIR, 1995).

Of particular concern, however, was the effect of the current during the release of February-March 1995 (Figure 7.6). This release coincided with an incursion of warm water from Angola down the coast. For a period of 21 days the buoys drifted southwards. The buoy released 15 km offshore following an erratic path which brought it very close to the coast on several occasions (Figure 7.6). The fastest average rate of southward movement of this buoy was about 20 cm/s over one seven-day period and 33 cm/s over one two-day period.

The results of these drifter surveys, although falling well short of being comprehensive, suggest that oil spilled within about 25 km of the coast has very little chance of being washed ashore and will eventually drift further out to sea. The closer one gets to the shore, the greater become the chances of oil drifting ashore. However, even within 5 km of the shore, the chances of spilt oil drifting out to sea are greater than they are of it drifting ashore.

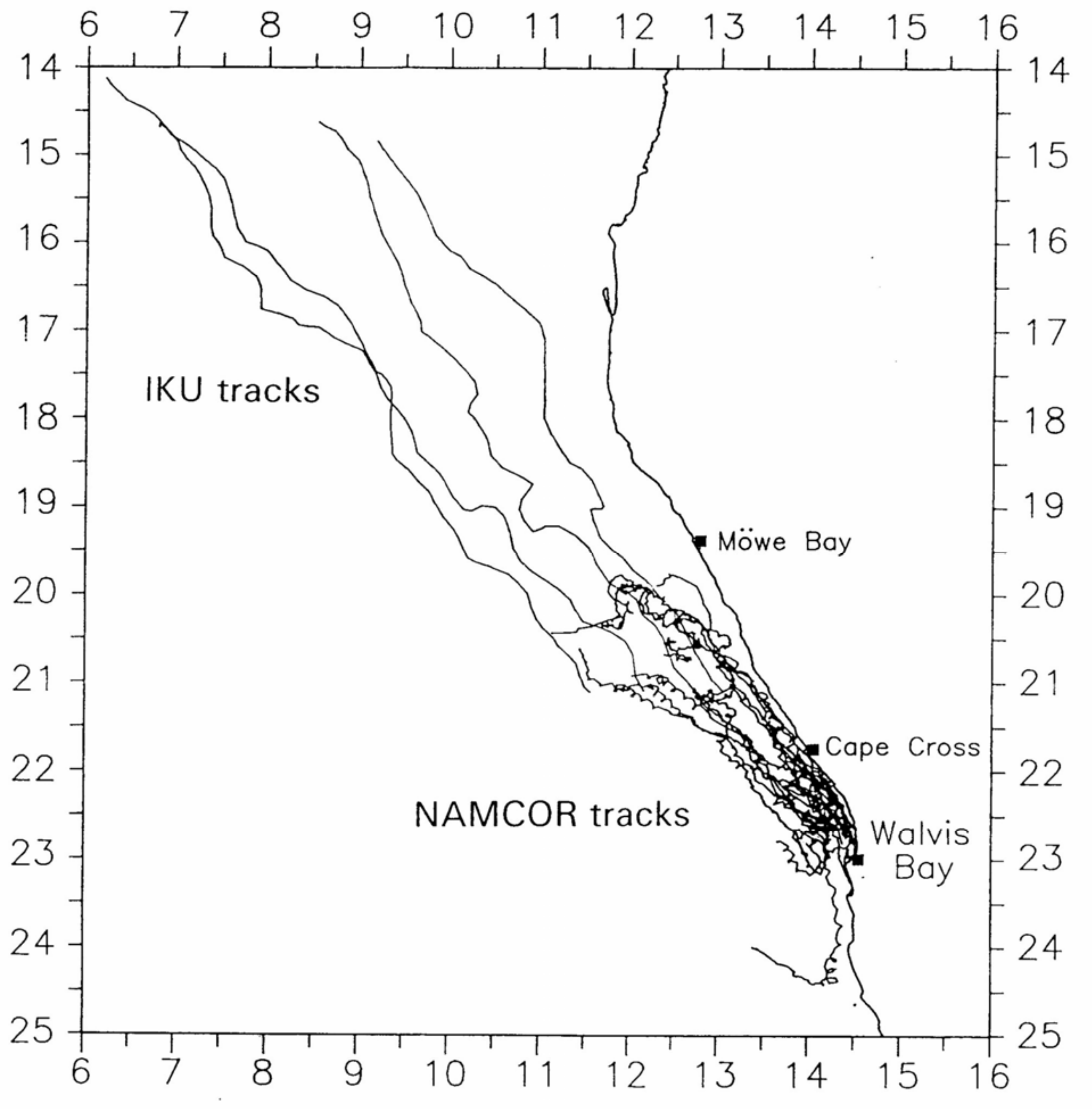

Figure 7.2: IKU and NAMCOR drifter buoy tracks off the northern coast of Namibia (from CSIR, 1995)

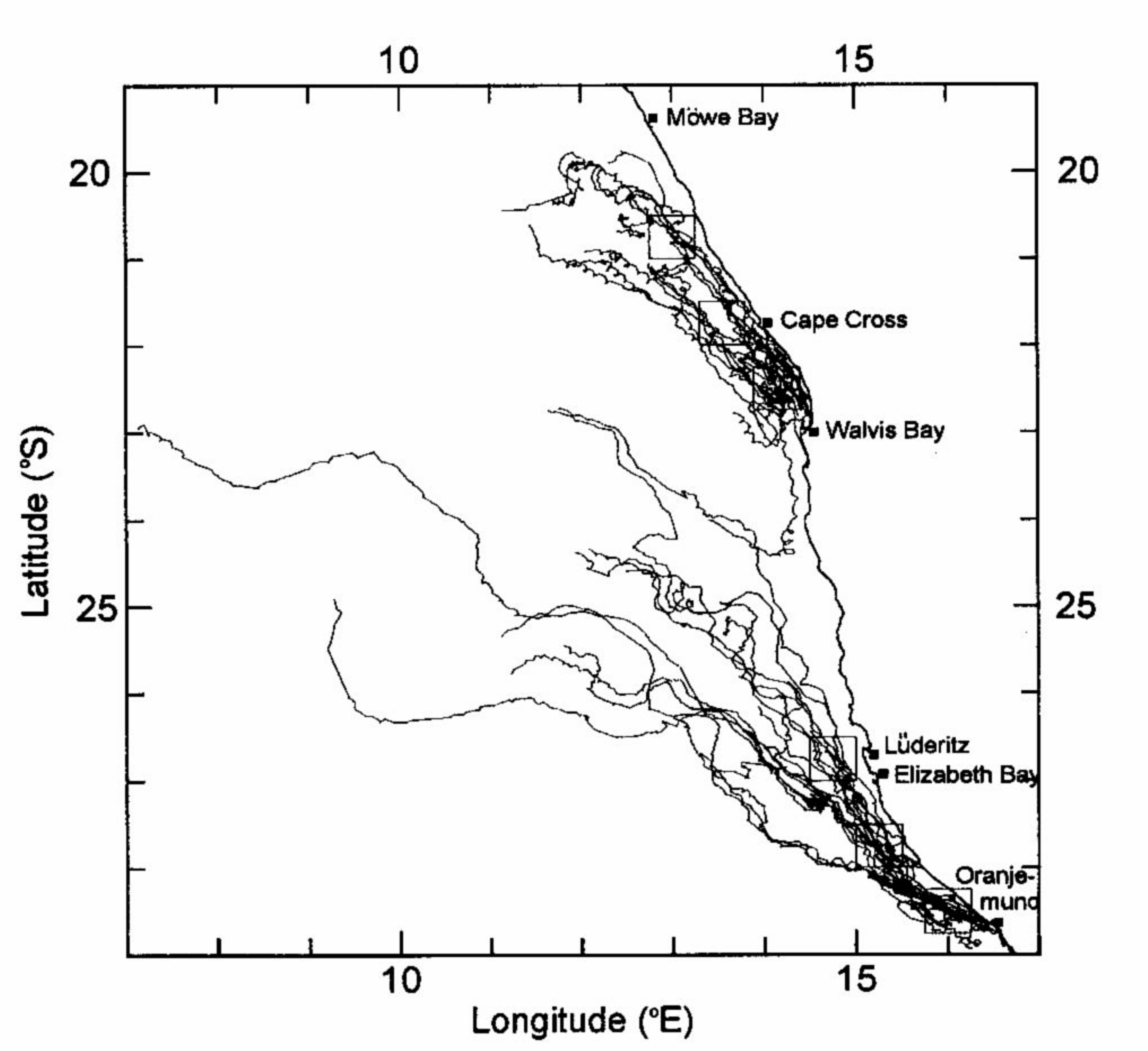

Figure 7.3: Composite of all drifter buoy tracks (from Gründlingh, 1999)

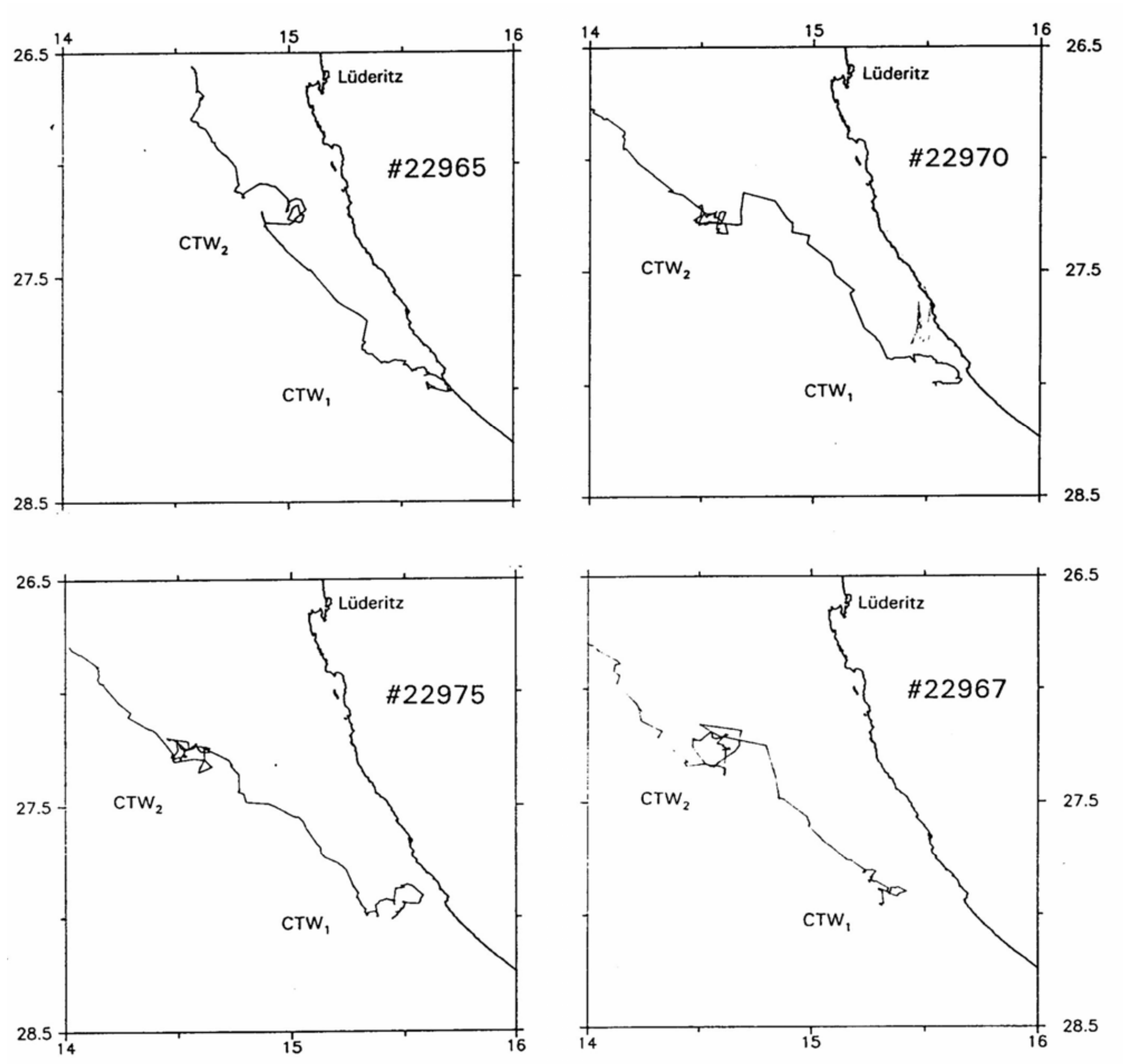

Figure 7.4: ***Partial tracks of drifter buoys released in October 1994 showing the effect of two shelf waves CTW1 and CTW2 (from CSIR, 1995)***

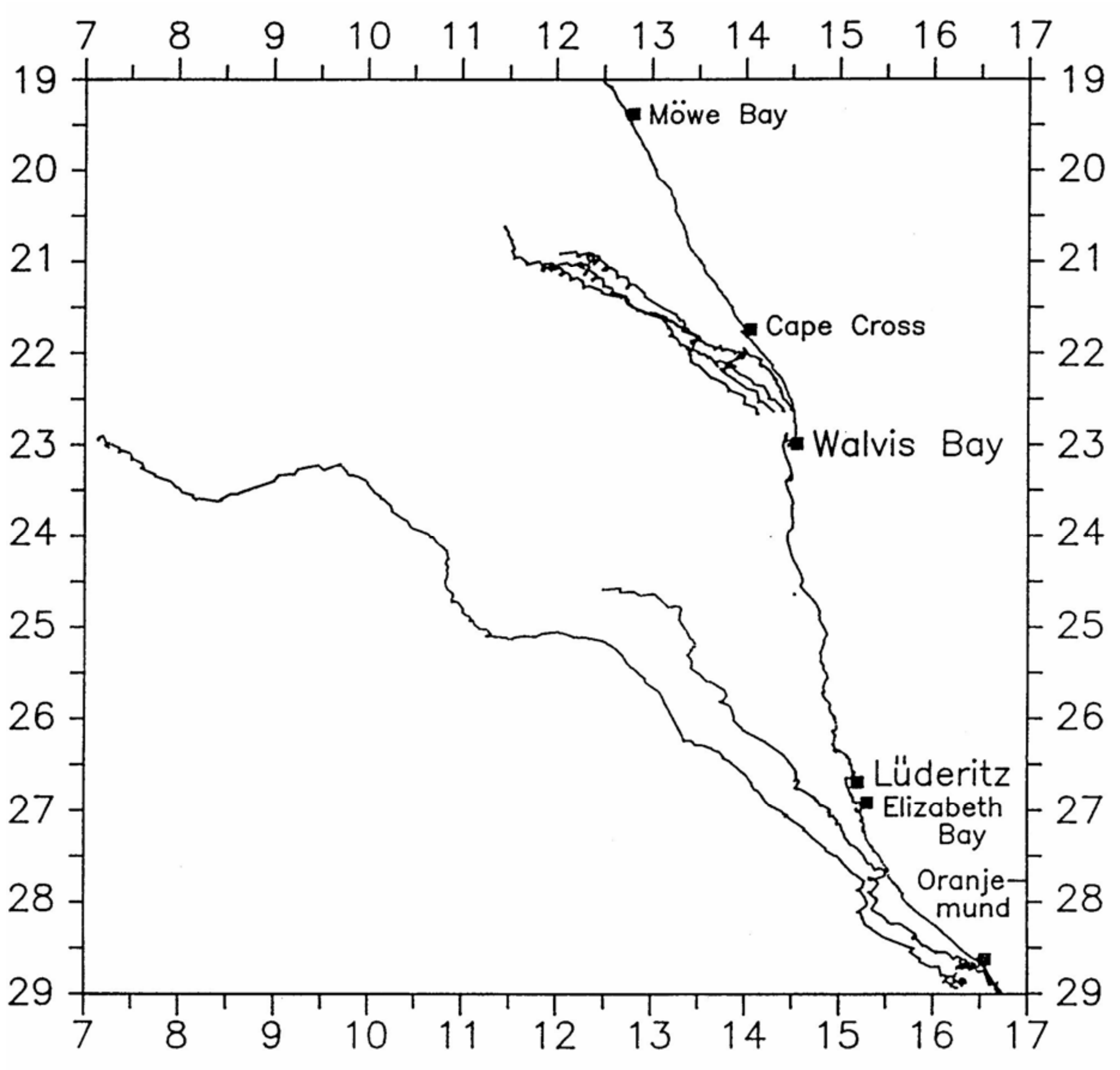

Figure 7.5: Tracks of drifter buoys deployed in December 1994 (from CSIR, 1995)

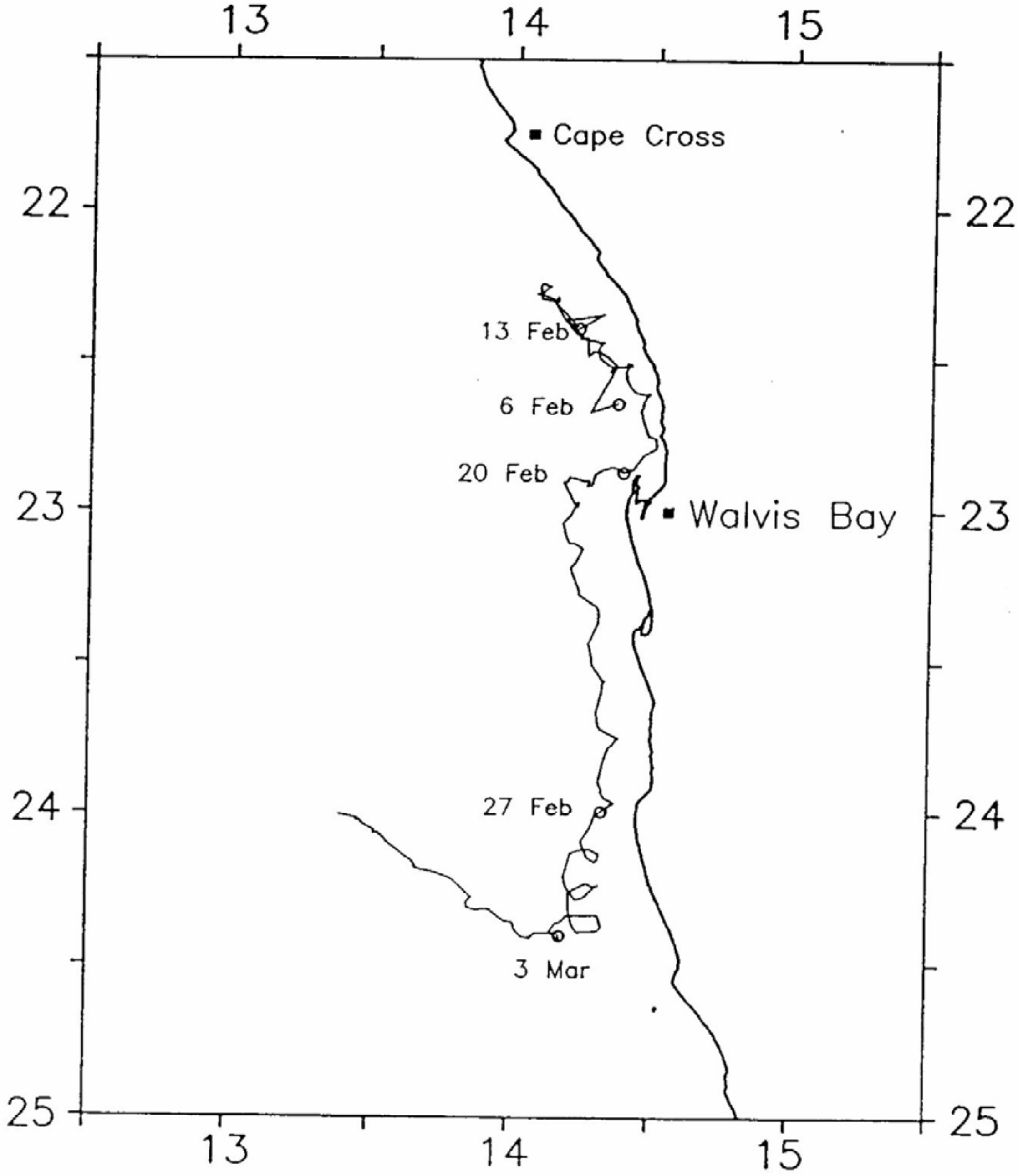

Figure 7.6: Track of drifter buoy # 22982 deployed during February 1995 (from CSIR, 1995)

CHAPTER 8:

LEGISLATION AND POLICY

Contents

8. LEGISLATION AND POLICY 8.1
8.1 Draft Decree on Environmental Protection for the Petroleum Industry...................................... 8.2

8. LEGISLATION AND POLICY

ANGOLA

Introduction

Environmental aspects of exploration and production (E&P) operations in Angola are regulated by the Ministry of Petroleum in collaboration with the national oil company Sociedade Nacional de Combustiveis de Angola, U.E.E., (SONANGOL)1. With the forthcoming adoption of the General Environment Law (GEL), increasing responsibility for the implementation of national environmental policy will rest with the Minister for Fisheries and the Environment.

Ministry of Petroleum

Overall responsibility for the management of onshore and offshore oil and gas E&P activities rests with the Ministry of Petroleum. In particular, the Ministry is entrusted with:

- Promoting the exploration and development of petroleum resources.
- Directing the activities of petroleum sector companies.
- Reviewing and proposing the measures required to achieve the national objectives of evaluating, upgrading and renewing Angola's energy reserves.

Within the Ministry, these responsibilities are carried out by a number of different departments including: the National Petroleum Directorate, the Planning Department, the Legal Department and the Foreign Marketing Department. In particular, the National Petroleum Directorate (Direccao Nacional dos Petroleos) has industrial sector-specific responsibilities for nature conservation and environmental protection through its Office for the Protection of the Environment (Gabinete de Proteccao Ambiental). The Office for the Protection of Environment is actively involved in the development of the National Contingency Plan (Combat a poluicao) and its stated objective is to develop the mechanisms and instruments (legal and administrative), within the National Environmental Protection System (Sistema de Proteccao Ambiental), to control activities in the petroleum industry.

Although routine management of petroleum operations rests with the state oil company, SONANGOL, exploration and production contracts are negotiated under the supervision and guidance of the Ministry of Petroleum. Furthermore, with the implementation of the forthcoming environmental, health and safety legislation, the Ministry of Petroleum is set to become increasingly responsible for the review and approval of EIA studies, proposed environmental management systems, emergency response plans and site abandonment and rehabilitation plans. For example, the Draft Decree on Environmental Protection for the Petroleum Industry covers EIAs, spill prevention and response, waste management, management of operational discharges and site abandonment and rehabilitation.

Ministry of Fisheries and Environment

The Ministry of Fisheries and Environment is the state body responsible for the development and co-ordination of national environmental policy and the National Environmental System, and for the management of fish stocks and fisheries.

In terms of Article 16 of the General Environmental Law (Law No. 5/98 of 19 June 1998) environmental impacts assessments are mandatory "for all activities which have an impact on the balance and well-being of the environment and society".

In accordance with the provisions of the Draft Decree on Environmental Protection for the Petroleum Industry, Environmental Impact Assessments (EIA) carried out in support of applications for E&P authorisations are submitted to the Ministry (via the Ministry of Petroleum) for review and approval.

Petroleum Industry Operator's Environmental, Health and Safety Committee

The environmental, health and safety interests of operators in Angola are represented by a dedicated committee, which has been active in the development and review of both framework and petroleum sector-specific environmental legislation.

8.1 Draft Decree on Environmental Protection for the Petroleum Industry

The Draft Decree on Environmental Protection for the Petroleum Industry was drawn up by the Angolan Ministry of Petroleum, Cabinda Gulf Oil Company Limited, Elf Exploration Angola and Texaco Panama Inc. Angola on 7 May 1993. Articles 1 - 3 of the Draft Decree set the basic objectives which govern oil exploration and production in Angola. These are:

Article 1 : Object

This Decree regulates the protection of the Environment in the course of petroleum activities in order to guarantee its preservation, namely in respect of human health, water, land, air, flora and fauna, ecosystems, landscape, atmosphere and the cultural, archaeological and aesthetic values.

Article 2 : Scope

This Decree shall cover all petroleum activities, either onshore or offshore, under the authority of the Ministry of Petroleum.

Article 3 : General Obligations

(i) Concessionaire and the Associates, through the Operator, shall take the necessary precautions to prevent the negative effects of pollution and the evacuation of wastes and to limit, to the extent possible, the consequences if they have already occurred.

(ii) The Concessionaire and the Associates, through the Operator, shall advise the personnel that perform such work, as well as the companies contracted or sub-contracted for that purpose, to comply with the present Decree.

NAMIBIA

Legislated requirements for environmental protection during petroleum exploration and production

The Petroleum (Exploration and Production) Act, 1991 requires that a baseline study of the environment likely to be affected by exploration operations is carried out prior to the start of the first seismic survey in the relevant licence area. Full environmental impact assessments must be carried out prior to the start of exploration drilling and prior to development of any commercial discovery.

The details of environmental protection measures to be undertaken are spelt out in Chapter 11 of the Model Petroleum Agreement, 1998. Since the petroleum exploration EIAs so far conducted offshore Namibia have been so comprehensive and have covered such large areas, the Model Petroleum Agreement, 1998 permits a licensee applying for a new licence and who has already conducted an extensive EIA offshore Namibia to use his own existing EIA (if the new licence area is close to the old area) or that of another licensee (if the new licence area is far from the old area and provided the other licensee agrees thereto) as the EIA for the new area provided that the Minister of Mines and Energy and the Ministries of Fisheries and Marine Resources and Environment and Tourism agree in writing to this step. This applies to exploration but because each production operation has its own unique problems, it will not apply to EIAs covering production.

Rehabilitation at the end of production is a problem both in the petroleum and the mining industries. The Petroleum Laws Amendment Act, 1998 introduced the requirement that half way through the life of a producing petroleum field, the licensee was to start making contributions to a decommissioning and rehabilitation fund which was to be established to cover the cost of decommissioning on cessation of production operations. Contributions to this fund are tax deductible in terms of the Income Tax Act, 1981.

The Petroleum (Exploration and Production) Act, 1991 and the Model Petroleum Agreement further require that operations are conducted "… diligently, expeditiously, efficiently and in a proper, safe and workmanlike manner" and "in accordance with Good Oilfield Practices." The act defines Good Oilfield Practices as meaning "any practices which are generally applied by persons involved in the exploration or production of petroleum in other countries of the world as good, safe, efficient and necessary in the carrying out of exploration operations or production operations." Thus, environmental protection measures also include safe work practices.

The Petroleum (Exploration and Production) Amendment Act, 1994 permits the operator to discharge cutting from wells drilled with water-based drilling muds to be discharged overboard provided prior approval from the Minister of Mines and Energy has been obtained.

Compliance by licensees with legislated requirements for environmental protection

All licensees have prepared pre-seismic baseline studies and pre-drilling EIAs. These have all been carried out in continuous and close liaison with NAMCOR, which oversaw and coordinated the whole process, and the following ministries: Mines and Energy, Fisheries and Marine Resources, Environment and Tourism, Works Transport and Communication, and Health and Social Services. Public scoping meetings were held at an early stage of each EIA and meetings between the licensee and all the above concerned parties were held at regular intervals during preparation of the EIA. Representatives from government ministries therefore had regular opportunities to monitor progress and ensure that their particular concerns were given attention. The baseline studies covered all aspects of the environment in the licence area and in a huge area surrounding the licence. Maps of fishing grounds and spawning areas were included.

Using, building on and incorporating the baseline study results, the EIAs for prospect drilling consisted of four parts: a description of the drilling process, including supply boats and flying activities, all aspects of the environment, those aspects of the environment that might be affected by the drilling operation or by oil spills, and mitigation measures. Thus, the section on the drilling process elaborated on potentially polluting activities and materials and all waste materials and included specific sections on drilling muds, blowout prevention, flow testing, plugging and abandonment, radioactive well logging devices, air emissions, discharges to water (drill cuttings, drilling mud, cement and cement additives, deck drainage, water from machinery spaces and ballast tanks, hydraulic fluids from the blow out preventer, sewage, galley waste and detergents). Combustible waste was to be burnt on the rig. Each item of waste for land-based disposal was covered B rubbish and trash, lumber, packaging material and tyres, scrap metal, drums and containers, chemicals and hazardous waste, laboratory waste, infectious waste, and filters and filter media.

All EIAs were required to include oil spill drift simulations for distances of up to 300 km down current of potential well locations. Behaviour and toxicity of oil in water was also covered. Some of the EIAs such as that by Chevron (1994) have included maps of the nature of long lengths of coastline, including that of neighbouring countries, which might be affected by an oil spill. They have also indicated the sensitivity of each stretch of the coast as determined by the local authorities and experts.

The EIAs by petroleum exploration licensees are the most comprehensive ever carried out in Namibia and have been instrumental in setting standards for EIAs in Namibia and for teaching many Namibians what EIAs are all about and what they should accomplish.

SOUTH AFRICA

Under the Mining Rights Act, Act 20 of 1967 all rights to natural oil (which term includes oil and gas) are vested in the State. The rights for the continental shelf and territorial waters of South Africa were ceded to SOEKOR (Pty) Ltd under a prospecting lease (OP 26) dated 23 June 1967. This lease expires on 20 June 2007 (Fuggle and Rabie (eds), 1992).

SOEKOR is empowered to sublease areas, subject to the approval of the responsible Minister, to financially and technically competent oil exploration companies. In the event of a discovery of a minimum defined size being made, SOEKOR must apply to the Minister for a mining lease for itself or on behalf of a sublease holder. The mining lease, if granted, is valid until the field can no longer be exploited commercially.

The Minerals Act, Act 50 of 1991 came into effect in January 1992. This Act has three main objectives:

1. Consolidation and rationalization of nine mineral laws. Of interest here is that the Mining Rights Act, Act 20 of 1967, under which petroleum rights were vested in SOEKOR was repeated with exception of the chapter relating to dealing in unwrought precious metal.

2. Promotion of government policy in respect of privatization and deregulation. This is to be achieved by the reduction of state involvement, and the introduction of a simplified system of granting permits or licences for prospecting to the holder of the right to any mineral.

3. Promotion of environmentally responsible mining. The objective is to ensure that minerals are optimally and safely mined and that the surface damaged by mining operations is properly rehabilitated both during and after mining operations.

In terms of section 39 of the Minerals Act, Act 50 of 1991, Environmental Management Programme Reports (EMPRs) are required for both prospecting and mining (petroleum production). The format for the EMPRs is laid down in the Guidelines for the Preparation of Environmental Management Programme Reports for Prospecting for and Exploitation of Oil and Gas in the Marine Environment issued by the Department of Minerals and Energy (DME).

A key component of the EMPR is an environmental impact assessment of the proposed exploration or production operation. The guidelines do not specify the EIA procedure to be used, however most practitioners have undertaken the EIAs in accordance with the IEM process described in the Integrated Environmental Management Procedure (Department of Environment Affairs, 1992). The IEM procedure places great emphasis on public participation in the EIA to ensure that all the relevant issues are addressed in the impact assessment.

In order to reduce the time and cost incurred in the duplication of information that takes place in compiling an EMPR for each exploration programme, and to standardise as many issues as possible, the concept of a generic EMPR was raised by the industry. Following a suggestion of the DME, SOEKOR PLU has initiated a project to prepare separate Generic EMPRs for (a) seismic surveys and (b) prospect well drilling, for the whole of the South African offshore. It should be noted that the Generic EMPR is directed at exploration/prospecting operations and does not extend to development and production operations that will require their own specific EMPRs. A summary of the objectives and contents of the Generic EMPR is presented below (see box).

Once the Generic EMPRs are approved by DME, exploration companies (as Prospect Permit holders) will each be required to comply separate "lease-specific" EMPRs for exploration operations in their licence areas using the standard templates provided in the Generic EMPRs. Exploration companies will also be obliged to complete "close-out" reports at the end of each seismic or prospect well drilling operation.

GENERIC ENVIRONMENTAL MANAGEMENT PROGRAMME
FOR OIL AND GAS EXPLORATION IN
THE SOUTH AFRICAN OFFSHORE

- The Generic EMP report deals with exploration operations in the whole of the offshore out to the 200 nautical mile limit of the Exclusive Economic Zone. Public meetings were held to explain the process and to solicit issues that need to be addressed in the EMP report. Some 400 Interested and affected parties have been contacted.
- The EMP report includes :
  - An environmental baseline report.
  - Separate Environmental Impact Reports for (a) Seismic Surveys and (b) Prospect Drilling Operations.
  - Separate Generic Environmental Management Programme Reports for (a) Seismic Surveys and (b) Prospect Drilling Operations.
  - Digital templates to provide uniformity and to assist in the compilation of :
    - Specific EMPRs for each exploration permit holder.
    - Project Close-out Reports for each seismic survey and prospect drilling operation.
- Each specific EMPR will include a schedule of actions that an operator must undertake in the course of operations.
- The Close-out Report requires the operator to record all volumes of materials that are disposed of (or left) in the marine environment and in onshore waste dumps and all impacts and steps taken to mitigate the impacts.
- The system facilitates auditing and a process of continual improvement.
- The project is being co-funded by the SOEKOR Petroleum Licensing Unit and the petroleum exploration companies that are operating in the South African offshore.

One of the requirements of the SOEKOR sub-lease contracts is that operators are required (upon abandonment or completion of a well) to remove all guidebases and other substantial equipment so as to leave the seafloor free of significant obstruction. The only exception to this requirement is where a well is capped, to be used later as a production well. The conditions of a mining lease likewise require that wellheads are removed from production well prior to the abandonment of a field.

Acts and agreements relating to the combatting of oil pollution include:

The Prevention and Combatting of Pollution of the Sea by Oil Act (No. 6 of 1981) gives the Minister of Transport Affairs wide-ranging powers regarding the prevention of oil pollution. However, in terms of

Notice No. 1646 in Government Gazette No. 10377 of 8 August 1986, any power, duty or function regarding the combatting of pollution of the sea by oil has been assigned to the Minister of Environmental Affairs and Tourism with effect from 20 May 1986. This gives the Minister of Environmental Affairs and Tourism specific responsibility for environmental protection and clean-up aspects of oil spills. During an incident, either Minister will be able to order any person who is capable, to supply goods or services required for the removal of such pollution. The responsibility for initiating and coordinating the necessary actions to effect protection and clean-up operations lies with the Departmental Officers to whom the Ministerial powers have been delegated. Various functions may also be delegated to Local Authorities and other relevant bodies.

Regulation 38(3) for the harbours of the Republic of South Africa, promulgated by the Minister of Transport Affairs under powers vested in him by Section 73(1) of Legal Succession of The South African Transport Services Act (No. 9 of 1989), makes the provisions of the Prevention and Combatting of Pollution of the Sea by Oil Act (Act No. 6 of 1981), applicable to the waters of a harbour under the jurisdiction of Portnet.

CHAPTER 9:

INTERNATIONAL CONVENTIONS AND ENVIRONMENTAL LAW

Contents

9. INTERNATIONAL CONVENTIONS AND ENVIRONMENTAL LAW 9.1

9. INTERNATIONAL CONVENTIONS AND ENVIRONMENTAL LAW

ANGOLA

Introduction

Angola is signatory to a very limited number of international conventions and treaties governing environmental protection. Most notably these do not include MARPOL 73/78 which is one of the few global laws prescribing quantitative environmental standards for operational aspects of offshore exploration and production activities.

In terms of the 1975 Constitution no treaty to which the Republic of Angola is signatory has the force of law until it is enacted into law by the National Assembly.

International Conventions

International conventions relevant to the environmental aspects of E&P operations to which Angola is party include:

- United Nations Convention to Combat Desertification in those Countries Experiencing Serious Drought and/or Desertification, particularly in Africa 1994: Angola is a signatory;
- United Nations Law of the Sea Convention (UNCLOS) 1982;
- Framework Convention on Climate Change (FCCC) 1992;
- Convention on Biological Diversity 1992.

The Angolan Council of Ministries has approved the following IMO Conventions:

- International Convention on Liability for Oil Pollution Damage (CLC 91)
- International Convention for the Prevention of Pollution from Ships (MARPOL 73/78)
- International Convention on the Establishment of an International Fund for Compensation for Oil Pollution Damage (FUND 92)
- International Convention on Oil Pollution Preparedness, Response and Co-operation (OPRC 90)

All necessary documentation has been prepared for the ratification by Angola of the:

- International Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter (LDC), 1972
- International Convention Relating to Intervention on the High Seas in Cases of Oil Pollution Casualties (INTERVENTION), 1969
- International Convention on Marine Search and Rescue (SAR), 1969

- International Convention on Limitation of Liability and Compensation for Damage in Connection with Carriage of Hazardous and Noxious Substances by Sea (HNS), 1996
- International Convention on Co-operation for the Protection of the Seabed of the Central and West Coasts of Africa (Abidjan), 1981
- Protocol on the Co-operation for Emergency Pollution Response (Abidjan), 1981.

Agenda 21

The United Nations Conference on Environment and Development (UNCED) held in Rio de Janeiro, Brazil resulted in the adoption of Agenda 21. Agenda 21 is an international programme aimed at achieving sustainable development in the 21st Century: it provides objectives and recommended actions for a range of environmental issues. Coastal states are encouraged to deal with marine pollution derived from both marine and terrestrial sources. With respect to E&P activities, coastal states are called upon to assess existing regulatory measures regarding pollution from offshore oil and gas platforms.

Industry-specific Environmental Guidelines

A number of guideline documents specific to E&P operations have been produced for use by the petroleum E&P industry. These include:

- International E&P Forum
  - Guidelines for the Development and Application of Health, Safety and Environmental Systems (1994)
  - Health, Safety and Environmental Schedules for Marine Geophysical Operations
  - Environmental Management in Oil and Gas Exploration and Production (1997)
  - Waste Management Guidelines (1993)

- International Association of Geophysical Contractors
  - Environmental Guidelines for World-Wide Geophysical Operations (1993).

NAMIBIA

Introduction

Similar to Angola, Namibia is signatory to a very limited number of international conventions and treaties governing environmental protection.

At present Namibia is preparing to become a signatory of MARPOL 73/78 but is limited by the lack of adequately trained manpower to implement it effectively.

International Conventions

- United Nations Law of the Sea Convention (UNCLOS) 1982. The territorial Sea and Exclusive Economic Zone of Namibia Act, Act 3 of 1990 undertakes to give effect to the United Nations Law of the Sea Convention.
- Convention on Biological Diversity, 1992.
- Convention on Wetlands of International Importance especially as Waterfowl Habitat, 1971 (Ramsar Convention).

  There are three listed wetlands under the Ramsar Convention in the Namibian BCLME area. These are: Walvis Bay lagoon, Sandwich Harbour and the Orange River mouth. The latter is the only transboundary Ramsar site in southern Africa.
- Convention on the Control of Transboundary Movements of Hazardous Wastes and their Disposal, 1994 (Basel Convention). This convention aims to ensure that any transboundary movement and disposal of hazardous wastes takes place in an environmentally sound and responsible manner.

SOUTH AFRICA

Introduction

South Africa is signatory to the following international conventions and agreements which have relevance to both the direct and indirect effects of offshore oil and gas exploration and production.

- Convention on Migratory Species of Wild Animals, 1991 (Bonn Convention).

  In particular whales and pelagic bird species which migrate from the Antarctic and Sub-Antarctic to overwinter in southern African waters are of interest to the E&P industry.
- Protocol for the Protection of the Ozone Layer, 1990 (Montreal Protocol).

  The flaring of gases from exploration and production wells could be an issue should large scale production occur. A certain amount of gas flaring is already done (with due authorisation) by Mossgas and Soekor E & P.
- Convention on Wetlands of International Importance especially as Waterfowl Habitat, 1971 (Ramsar Convention).

  There are three listed wetlands under the Ramsar Convention in the South African BCLME area, namely the Orange River mouth, Verlorenvlei, and Langebaan Lagoon in the West Coast National Park. A fourth site, the Berg River Estuary has been proposed for listing.
- Convention on the Control of Transboundary Movements of Hazardous Wastes and their Disposal, 1994 (Basel Convention).

  This convention aims to ensure that any transboundary movement and disposal of hazardous wastes takes place in an environmentally sound and responsible manner.
- Convention on Biological Diversity, 1992 (CBD).

The objective of the CBD is to effect international cooperation in the conservation of biological diversity. From the E&P perspective it is important in that it aims to foster sharing of the benefits arising from the utilization of natural resources.

- International Whaling Commission, 1946 (IWC).
  The IWC has broadened its interests from utilization of whales to the overall conservation of cetaceans worldwide.
- Framework Convention on Climate Change, 1992 (FCCC).
  The ultimate objective of this convention is to stabilise greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous interference with the global climate system.

CHAPTER 10:

ENVIRONMENTAL ISSUES ARISING FROM OFFSHORE OIL AND GAS EXPLORATION AND PRODUCTION

Contents

10. ENVIRONMENTAL ISSUES ARISING FROM OFFSHORE OIL AND GAS EXPLORATION AND PRODUCTION 10.1

10. ENVIRONMENTAL ISSUES ARISING FROM OFFSHORE OIL AND GAS EXPLORATION AND PRODUCTION

ANGOLA

The effects of petroleum exploration and production on the marine environment of Angola do not appear to have been documented. However, potential impacts and areas of conflict between the E&P industry and other users of the coast and sea are similar to those experienced elsewhere.

Seismic surveying

It is generally agreed that modern seismic surveying methods and operations are benign and have, at worst, a short-term, local impact on both the biotic and human environment (see Chapter 4).

In Angolan waters there may be some interference with shipping and fishing activities during seismic surveys, particularly 3-D surveys which tend to be of longer duration as a result of the greater density of tracklines required.

Seismic surveys may have an adverse effect on marine mammals such as humpback whales. However, in a recent (1999) unpublished report to the International Whaling Commission it was stated "…… humpback whales are still using the Angolan breeding ground, and annually migrate through the oil production fields in some numbers".

NAMIBIA

The Namibian offshore E&P activity is currently restricted to the Kudu gas discovery on the very south of the country's continental shelf. No liquid petroleum has been discovered in Namibian waters. At all times E&P activity has been very limited consisting of seismic surveys and a handful of exploration wells.

Conflicts between users of the sea and exploration operations were of short duration if any at all. There are potential conflicts between the trawling industry and the development of the Kudu gas field. The probable pipeline route has been closed to trawling for a number of years as a conservation measure. Nevertheless the fishing industry could place pressure on the authorities to permit bottom trawling. The more immediate conflict arises from the pipeline traversing potentially rich marine diamond deposits in the Atlantic 1 concession area off Oranjemund. Surveys are being undertaken currently to assess which pipeline route will have the least impact on the diamond mining operation.

The exploration activity in Namibian waters has served as an impetus for the establishment of a national oil spill contingency plan despite the fact that exploration has been entirely incident-free. The plan, however, has relevance to possible future spills arising from shipping accidents.

SOUTH AFRICA

The focus of the South African E&P industry has been the western Agulhas Bank (Bredasdorp Basin) which is beyond the scope of this study. Seismic surveys have been undertaken in the BCLME area, the most recent having been a 3-D survey off Hondeklip Bay (Block 2) in March 1999. 30 wells have been drilled in the BCLME area the most recent having been completed in 1992. Of the 30 wells drilled, 6 well-heads were recovered, one was capped and the remaining 23 were abandoned.

Unlike the Agulhas Bank, where there are numerous well-head structures causing obstructions on important fishing grounds, no conflicts between exploration activities and fishing have been reported. Similarly no conflict between marine diamond prospecting and mining operations has been reported despite the fact that the petroleum exploration lease blocks and the marine diamond mining concession areas overly one another. This may change if gas developments result in pipelines to shore and if diamond mining is carried out on a more extensive basis.

No significant impacts on marine biota have been reported and none is likely to be expected given the low intensity of petroleum and diamond exploration in the South African BCLME area. However, interest is developing in the possibility of mining agricultural (phosphorite and glauconite) and construction industry (sand and limestone) minerals, i.e. low value/high volume mining. Further, the concept of strip mining and extraction of all minerals, including diamonds is being investigated. If this were to occur the impact on the marine biota would be considerably greater than present.

CHAPTER 11

INFORMATION GAPS

Contents

11. INFORMATION GAPS 11.1

11. INFORMATION GAPS

ANGOLA

Angola is the only BCLME country producing significant quantities of oil. In Cabinda and northern Angola there are production platforms and pipelines which pose a potential risk, however remote, of releasing oil which could have a serious impact on the environment.

There is an urgent need to develop a coastal sensitivity atlas of the Angolan coast for oil spill contingency and response planning. To achieve this will require coastal surveys to provide information on landforms, flora, fauna and socio-economically important features e.g. saltworks (salinas), power station intakes, beach-based artisanal fishing, etc.

In terms of seismic surveys, the work on humpback whales sponsored by Texaco Panama Inc., Angola should be continued and expanded to include other cetaceans to ensure that seismic survey has the minimum impact on migration and breeding.

Oceanographic data for oil spill modelling and for drill cuttings dispersal studies is required to improve prediction and assessment of impacts. In particular persistence data for wind, i.e. how long does the wind blow from a given direction at a particular strength, would greatly improve oil spill trajectory predictions. Similarly, time-series of current strengths and directions through the water column (using acoustic doppler current profilers) would bring greater confidence to the prediction/assessment of the impacts of drill cuttings disposed of overside.

NAMIBIA

Perhaps the most important information gap in Namibia pertains to persistence data for wind. Besides being important for E&P contingency planning it has application for any spoil regardless of the source. Similar to Angola there is a need for current data for drill cuttings dispersal studies but given the results of prospecting to date this is not a high priority. Should there be renewed seismic survey activity better data on the status of cetaceans in Namibian waters would be required.

SOUTH AFRICA

Similar to Angola and Namibia there is a need for oceanographic data for oil spill and drill cuttings dispersal studies. Information on the coastal (including inter- and sub-tidal zones) flora and fauna of the Namaqualand coast i.e. between the Orange and Olifants Rivers requires to be improved for oil spill contingency planning purposes.

The status of cetaceans on the South African west coast has received little attention to date. Should intensive seismic surveying be undertaken in this area, surveys of the species, numbers and distribution of whales and dolphins should be undertaken.

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Contents

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