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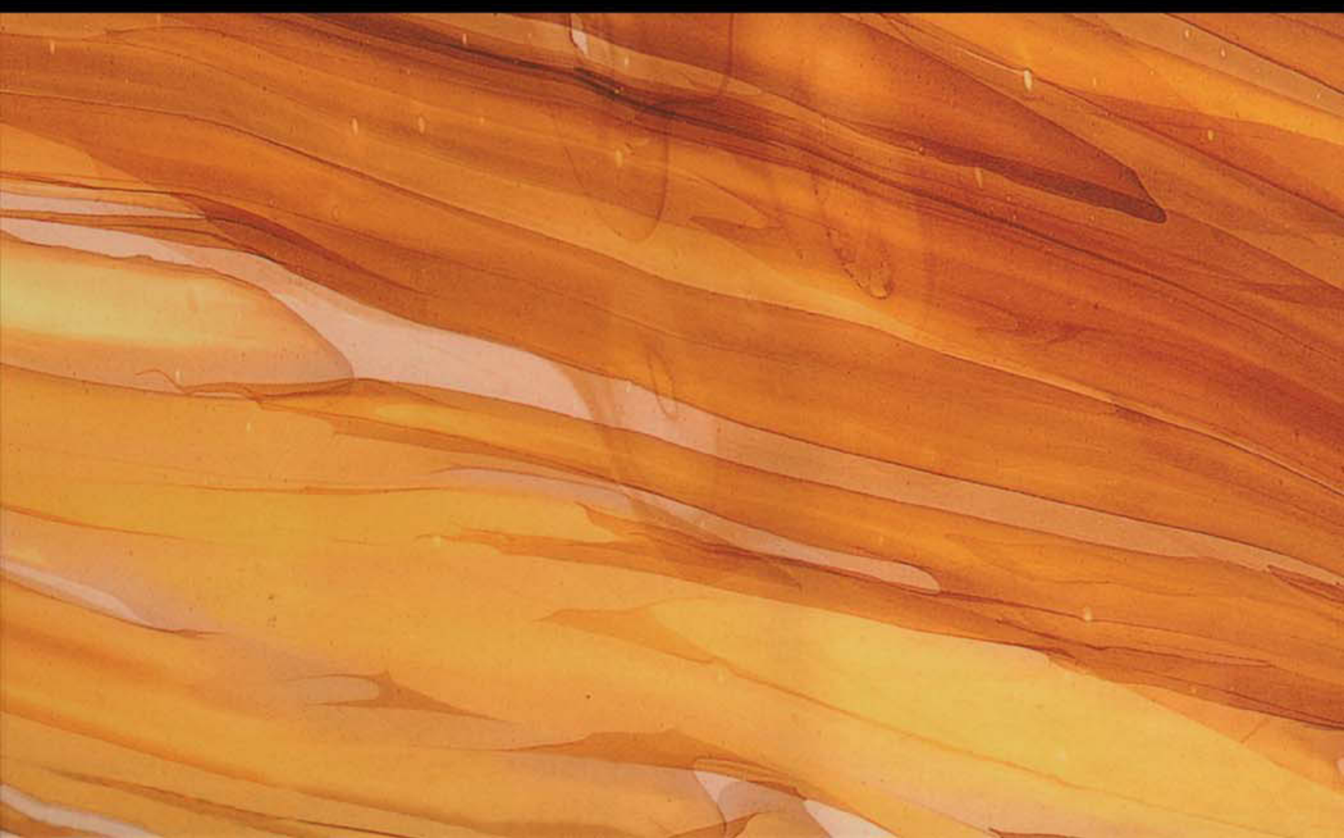
55

HYDROCARBON EXPLORATION AND PRODUCTION

2ND EDITION

FRANK JAHN, MARK COOK & MARK GRAHAM



VOLUME FIFTY FIVE

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Volumes 1-7, 9-18, 19b, 20-29, 31, 34, 35, 37-39 are out of print.

8	Fundamentals of Reservoir Engineering
19a	Surface Operations in Petroleum Production, I
30	Carbonate Reservoir Characterization: A Geologic-Engineering Analysis, Part I
32	Fluid Mechanics for Petroleum Engineers
33	Petroleum Related Rock Mechanics
36	The Practice of Reservoir Engineering (Revised Edition)
40a	Asphaltenes and Asphalts, I
40b	Asphaltenes and Asphalts, II
41	Subsidence due to Fluid Withdrawal
42	Casing Design – Theory and Practice
43	Tracers in the Oil Field
44	Carbonate Reservoir Characterization: A Geologic-Engineering Analysis, Part II
45	Thermal Modeling of Petroleum Generation: Theory and Applications
46	Hydrocarbon Exploration and Production
47	PVT and Phase Behaviour of Petroleum Reservoir Fluids
48	Applied Geothermics for Petroleum Engineers
49	Integrated Flow Modeling
50	Origin and Prediction of Abnormal Formation Pressures
51	Soft Computing and Intelligent Data Analysis in Oil Exploration
52	Geology and Geochemistry of Oil and Gas
53	Petroleum Related Rock Mechanics
55	Hydrocarbon Exploration and Production

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By

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Contents

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Introduction: About This Book

'Hydrocarbon Exploration and Production' takes the reader through all the major stages in the life of an oil or gas field, from gaining access to opportunity, through exploration, appraisal, development planning, production and finally to decommissioning. It straightforwardly explains the fiscal and commercial environment in which oil and gas field development takes place.

This comprehensive and current introduction to the upstream industry, is useful to industry professionals who wish to be better informed about the basic technical and commercial methods, concepts and techniques used. It is also intended for readers who provide support services to the upstream industry.

It draws together the many inter-disciplinary links within the industry in a clear and concise manner, while pointing out the commercial reason for the activities involved in the business – each chapter is introduced by pointing out the commercial application of the subject. The many illustrations are clear and plentiful, and are designed to maximise the learning while containing the detail necessary to preserve technical authenticity.

The authors are all practising consultants in the business, and have included the major advances in the industry in this latest edition, including technical methods for field evaluation and development and techniques used for managing risk within the business.

TRACS International has provided training and consultancy in Exploration and Production related issues for many clients worldwide since 1992. This book has gradually developed from course materials, discussions with clients and material available in the public domain.

F. Jahn
M. Cook
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CHAPTER 1

THE FIELD LIFE CYCLE

Introduction and Commercial Application: This section provides an overview of the activities carried out at the various stages of field development. Each activity is driven by a business need related to that particular phase. The later sections of this book will focus in more detail on individual elements of the field life cycle (Figure 1.1).

1.1. GAINING ACCESS PHASE

The first step an oil company will undertake in hydrocarbon exploration and production is to decide what regions of the world are of interest. This will involve evaluating the technical, political, economic, social and environmental aspects of regions under consideration. Technical aspects will include the potential size of hydrocarbons to be found and produced in the region, which will involve *scouting studies* using publicly available information or commissioning regional reviews, and a consideration of the technical challenges facing exploration and production, for example in very deep offshore waters.

Political and economic considerations include political regime and Government stability, the potential for nationalisation of the oil and gas industry, current embargoes, fiscal stability and levels of taxation, constraints on repatriation of profits, personnel security, local costs, inflation and exchange rate forecasts. Social

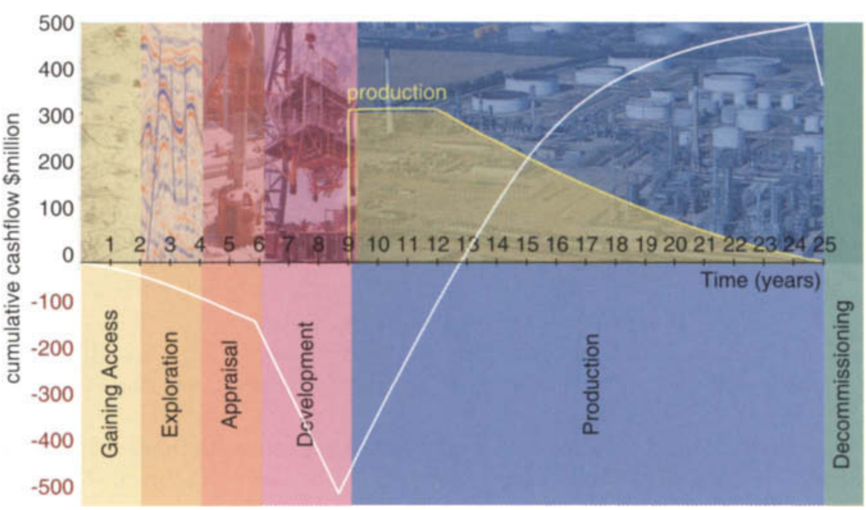

Figure 1.1 The field life cycle and typical cumulative cash flow.

considerations will include any threat of civil disorder, the availability of local skilled workforce and local training required, the degree of effort which will be required to set up a local presence and positively engage the indigenous people. The company will also consider the precautions needed to protect the environment from harm during operations, and any specific local legislation. There may also be a reputational issue to consider when doing business in a country whose political or social regime does not meet with the approval of the company's home Government or shareholders. Finally, an analysis of the competition will indicate whether the company has any advantage. It may be that if the company has an existing presence in-country from another business interest, such as downstream refining or distribution, the experience from these areas could be leveraged.

Some 90% of the world's oil and gas reserves are owned and operated by *National Oil Companies* (NOCs), such as Saudi Aramco (Saudi Arabia), Petronas (Malaysia), Pemex (Mexico). For an independent oil company to take a direct share of exploration, development and production activities in a country, it first needs to develop a suitable agreement with the Government, often represented by the NOC.

The invitation to participate may be publicly announced, in the form of a *licensing round*, as discussed in Chapter 2. Alternatively an arrangement for participation may be privately agreed with the NOC. In order to gain an advantageous position on this process, an oil company will expend effort to understand the local conditions, often by setting up a small presence in-country through which relationships are formed with key Government representatives such as the Oil and Gas Ministry, Department of Environmental Affairs and local authorities.

The understanding of local conditions and the requirements of the country, along with the relationships built, may result in a direct agreement for participation in the country or at least an advantageous position when a public bidding round occurs. The investment made during the *Gaining Access* phase may be considerable, especially in terms of time and the commitment of representatives – it may take a decade of setting up the groundwork before any tangible results are seen, but this is part of the investment process of hydrocarbon exploration and production.

1.2. Exploration Phase

For more than a century petroleum geologists have been looking for oil. During this period major discoveries have been made in many parts of the world. However, it is becoming increasingly likely that most of the 'giant' fields have already been discovered and that future finds are likely to be smaller, more complex, fields. This is particularly true for mature areas like the North Sea and the shallow water Gulf of Mexico (GoM).

Fortunately, the development of new exploration techniques has improved geologists' understanding and increased the efficiency of exploration. So although targets are getting smaller, exploration and appraisal wells can now be sited more accurately and with greater chance of success.

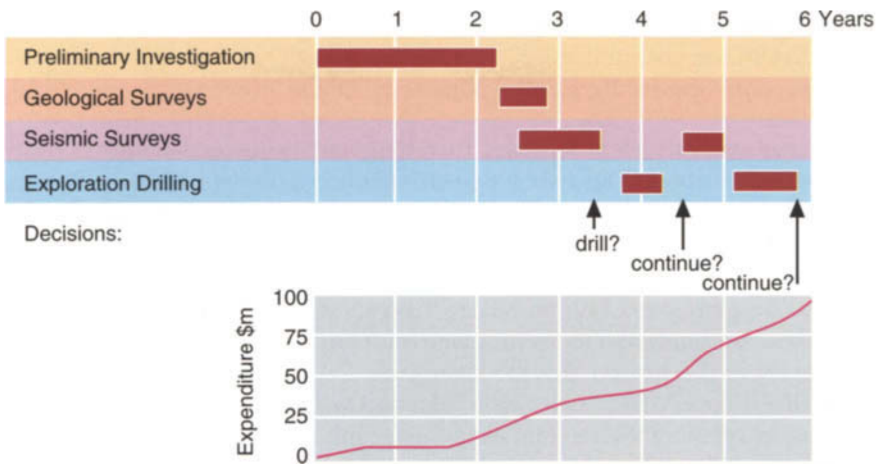

Figure 1.2 Phasing and expenditure of a typical exploration programme.

Despite such improvements, exploration remains a high-risk activity. Many international oil and gas companies have large portfolios of exploration interests, each with their own geological and fiscal characteristics and with differing probabilities of finding oil or gas. Managing such exploration assets and associated operations in many countries represents a major task.

Even if geological conditions for the presence of hydrocarbons are promising, host country political and fiscal conditions must also be favourable for the commercial success of exploration ventures. Distance to potential markets, existence of an infrastructure and availability of a skilled workforce are further parameters which need to be evaluated before a long-term commitment can be made.

Traditionally, investments in exploration are made many years before there is any opportunity of producing the oil (Figure 1.2). In such situations companies must have at least one scenario in which the potential rewards from eventual production justify investment in exploration.

It is common for a company to work for several years on a prospective area before an exploration well is 'spudded' – an industry term for starting to drill. During this period the geological history of the area will be studied and the likelihood of hydrocarbons being present quantified. Prior to spudding the first well a work programme will have to be carried out. Field work, magnetic surveys, gravity surveys and seismic surveys are the traditional tools employed. 'Exploration' in Chapter 3 will familiarise you in some more detail with the exploration tools and techniques most frequently employed.

1.3. Appraisal Phase

Once an exploration well has encountered hydrocarbons, considerable effort will still be required to accurately assess the potential of the find. The amount of data acquired so far does not yet provide a precise picture of the size, shape and producibility of the accumulation.

Four possible options have to be considered at this point

- To proceed with development and thereby generate income within a relatively short period of time. The risk is that the field turns out to be larger or smaller than envisaged, the facilities will be over or undersized and the profitability of the project may suffer.
- To carry out an appraisal programme with the objective of optimising the technical development. This will delay 'first oil' to be produced from the field by several years and may add to the initial investment required. However, the overall profitability of the project may be improved.
- To sell the discovery, in which case a valuation will be required. Some companies specialise in applying their exploration skills, with no intention of investing in the development phase. They create value for their company by selling the discovery on, and then move on with exploration of a new opportunity.
- To do nothing. This is always an option, although a weak one, and may lead to frustration on behalf of the host nation's Government, who may force a relinquishment if the oil company continues to delay action.

In the second case, the purpose of *appraisal* is therefore to reduce the uncertainties, in particular those related to the producible volumes contained within the structure. Consequently, the purpose of appraisal in the context of field development is not to find additional volumes of oil or gas! A more detailed description of field appraisal is provided in Chapter 8.

Having defined and gathered data adequate for an initial reserves estimation, the next step is to look at the various options to develop the field. The objective of the *feasibility study* is to document various technical options, of which at least one should be economically viable. The study will contain the subsurface development options, the process design, equipment sizes, the proposed locations (e.g. offshore platforms) and the crude evacuation and export system. The cases considered will be accompanied by a cost estimate and planning schedule. Such a document gives a complete overview of all the requirements, opportunities, risks and constraints.

1.4. Development Planning

Based on the results of the *feasibility study*, and assuming that at least one option is economically viable, a field development plan (FDP) can now be formulated and subsequently executed. The plan is a key document used for achieving proper communication, discussion and agreement on the activities required for the development of a new field, or extension to an existing development.

The FDP's prime purpose is to serve as a conceptual project specification for subsurface and surface facilities, and the operational and maintenance philosophy required to support a proposal for the required investments. It should give management and shareholders confidence that all aspects of the project have been identified, considered and discussed between the relevant parties. In particular, it should include

- objectives of the development
- petroleum engineering data
- operating and maintenance principles
- description of engineering facilities
- cost and manpower estimates
- project planning
- summary of project economics
- budget proposal.

Once the FDP is approved, there follows a sequence of activities prior to the first production from the field

- *FDP*
- *Detailed design* of the facilities
- *Procurement* of the materials of construction
- *Fabrication* of the facilities
- *Installation* of the facilities
- *Commissioning* of all plant and equipment.

1.5. Production Phase

The production phase commences with the first commercial quantities of hydrocarbons (first oil) flowing through the wellhead. This marks the turning point from a *cash flow* point of view, since from now on cash is generated and can be used to pay back the prior investments, or may be made available for new projects. Minimising the time between the start of an exploration campaign and 'first oil' is one of the most important goals in any new venture.

Development planning and production are usually based on the expected *production profile* which depends strongly on the mechanism providing the driving force in the reservoir. The production profile will determine the facilities required and the number and phasing of wells to be drilled. The production profile shown in Figure 1.1 is characterised by three phases

1. *Build-up period*	During this period newly drilled producers are progressively brought on stream.
2. *Plateau period*	Initially new wells may still be brought on stream but the older wells start to decline. Production facilities are running at full capacity, and a constant production rate is maintained. This period is typically 2–5 years for an oil field, but longer for a gas field.
3. *Decline period*	During this final (and usually longest) period, all producers will exhibit declining production.

1.6. Decommissioning

The *economic lifetime* of a project normally terminates once its net cash flow turns permanently negative, at which moment the field is decommissioned. Since towards the end of field life the capital spending and asset depreciation are generally negligible, economic decommissioning can be defined as the point at which gross income no longer covers operating costs (and royalties). It is of course still technically possible to continue producing the field, but at a financial loss.

Most companies have at least two ways in which to defer the decommissioning of a field or installation

(a) reduce the operating costs, or
(b) increase hydrocarbon throughput

In some cases, where production is subject to high taxation, tax concessions may be negotiated, but generally host Governments will expect all other means to have been investigated first.

Maintenance and operating costs represent the major expenditure late in field life. These costs will be closely related to the number of staff required to run a facility and the amount of hardware they operate to keep production going. The specifications for product quality and plant up-time can also have a significant impact on running costs.

As decommissioning approaches, *enhanced recovery*, for example chemical flooding processes are often considered as a means of recovering a proportion of the hydrocarbons that remain after primary production. The economic viability of such techniques is very sensitive to the oil price, and whilst some are used in onshore developments they can less often be justified offshore.

When production from the reservoir can no longer sustain running costs but the technical operating life of the facility has not expired, opportunities may be available to develop nearby reserves through the existing infrastructure. This has become increasingly common where the infrastructure already installed is being exploited to develop much smaller fields than would otherwise be possible. These fields are not necessarily owned by the company which operates the host facilities, in which case a service charge (*tariff*) will be negotiated for the use of third party facilities.

Ultimately, all economically recoverable reserves will be depleted and the field will be decommissioned. Much thought is now going into decommissioning planning to devise procedures which will minimise the environmental effects without incurring excessive cost. Steel platforms may be cut off to an agreed depth below sea level or toppled over in deep waters, whereas concrete structures may be refloated, towed away and sunk in the deep ocean. Pipelines may be flushed and left in place. In shallow tropical waters opportunities may exist to use decommissioned platforms and jackets as artificial reefs in a designated offshore area.

Management of decommissioning costs is an issue that most companies have to face at some time. On land sites, wells can often be plugged and processing facilities dismantled on a phased basis, thus avoiding high spending levels just as hydrocarbons run out. Offshore decommissioning costs can be very significant and less easily spread as platforms cannot be removed in a piecemeal fashion. The way in which provision is made for such costs depends partly on the size of the company involved and on the prevailing tax rules.

Usually a company will have a portfolio of assets which are at different stages of the described life cycle. Proper management of the asset base will allow optimisation of financial, technical and human resources.

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CHAPTER 2

Petroleum Agreements and Bidding

Introduction and Commercial Application: When the host government notifies its intent to offer exploration acreage, the oil company has an opportunity to *gain access*. In this section, we will introduce the form of invitation to bid and the agreement under which the oil company may compete for and explore that acreage. Two broad types of Petroleum Agreement exist: *Licence Agreements* and *Contract Agreements*.

In a Licence Agreement the Government issues exclusive rights to an oil company to explore within a specific area. The operations are financed by the licence holder who also sells all production, often paying a royalty on production, and always paying taxes on profits. Such a fiscal regime is often called a *Tax and Royalty system*. The Government may insist upon an obligatory level of State participation.

In a Contract Agreement, the oil company obtains the rights to an area through a contract with the Government or its representative NOC. Essentially the company acts as a contractor to the Government, again funding all operations. However, in this case, title to the produced hydrocarbons is retained by the Government, and the oil company is remunerated for its costs and provided a share of the profits either in cash or in kind (i.e. a share of the produced hydrocarbons). The most common form of this type of agreement is a *production sharing contract* (PSC), also known as a *production sharing agreement* (PSA), and more detail of this is provided in Chapter 14.

2.1. The Invitation to Bid

As Chapter 1 pointed out, the majority of the remaining world hydrocarbon reserves lie under the control of NOCs, and usually this will be developed by the NOC. Exceptions to this may arise for a variety of reasons. The NOC may not have the local expertise required, the host Government may not have sufficient funds or manpower or an asset may be unattractive to the NOC. In cases such as these, the host Government may invite third parties to participate in the region. Such an opportunity may be posted in the international press, trade journals or by specific invitation. The following is a typical invitation to bid (Figure 2.1).

The geographic area of interest is divided up into a number of blocks by a grid, which is usually orthogonal. The size of these blocks varies from country to country and even from area to area in some cases. For example, UK North Sea licence blocks are 10×20 km, Norwegian blocks 20×20 km, GoM blocks 3×3 miles and deepwater Angola blocks approximately 100×50 km (and roughly follow the shape of the coastline as shown in Figure 2.2).

The Government will decide at its discretion what blocks it wishes to include in any *bidding round*, but there is often a geographic progression, from say shallow water areas into deeper water as time moves on.

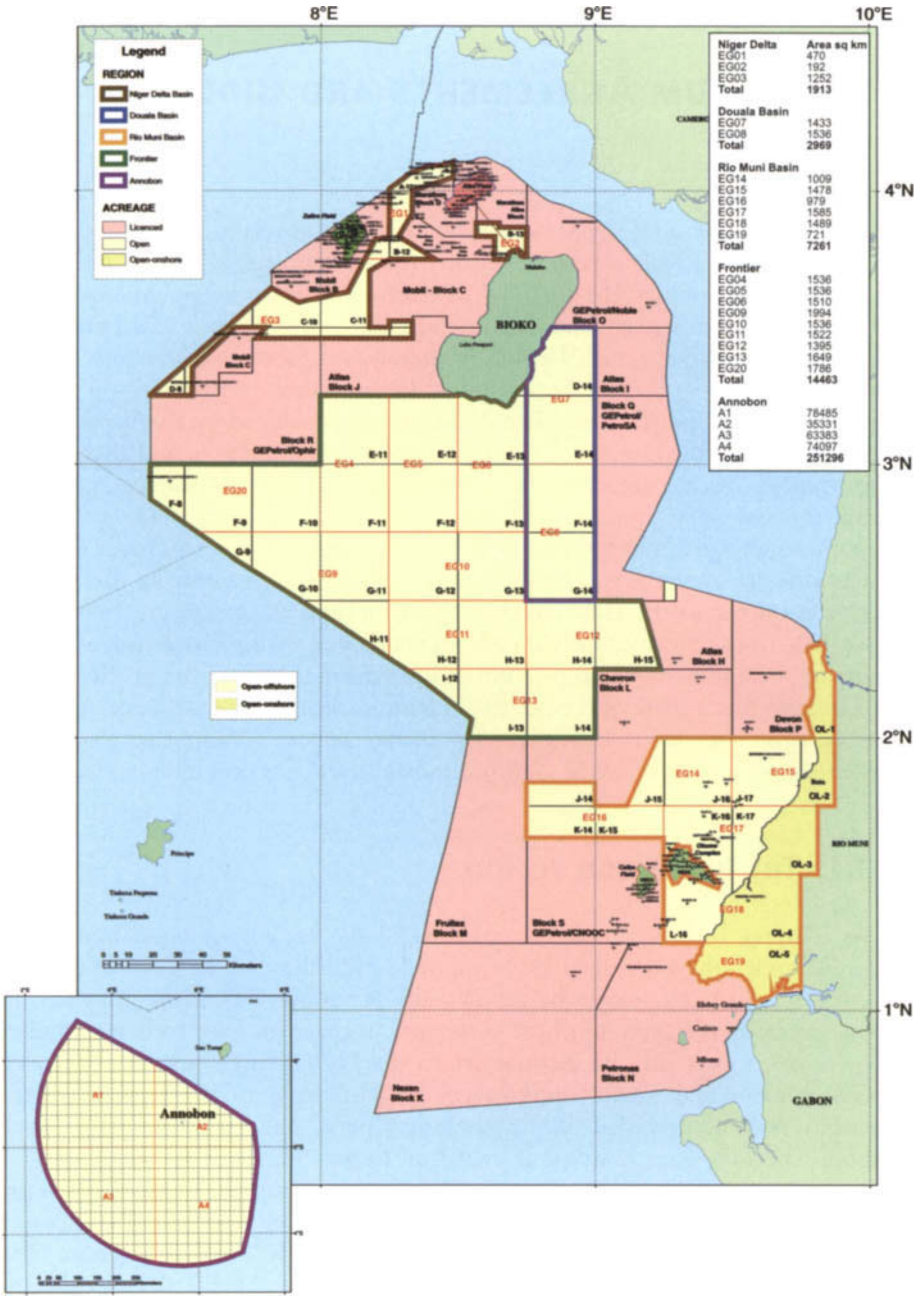

Figure 2.1 Licence map showing 2006 promotional blocks in Equatorial Guinea (source: www.equatorial.com).