CHAPTER - I

OCCURRENCE OF OIL IN INDIA

Introduction

For hundreds of millions of years the peninsular has been a comparatively stable block. At one time this stable block included what are now parts of Africa and Australia, and on the surface of this land mass, were large areas in which sediments accumulated. These sediments were relatively thin and included no marine sediments. Some fringe areas experienced sea encroachment on the low lying parts only. This relatively stable part of India has been termed by geologists, the 'Indian Shield'.

The eastern, northern and north western fringes of the peninsular India has a completely different history. During Mesozoic era, from about 70 to 200 million years ago, the seas which then lay to the north of what is now Peninsular India, were receiving a fairly large amount of sediments. But it was during the succeeding Tertiary Era that sedimentation continued at a particular rapid rate in the sinking basins off the eastern, north eastern and north western parts of peninsular India.

The sediments of these basins were from time to time subjected to important movement of the earth which crumpled the sediments and raised them above sea level. These movements culminated late in the Tertiary era when the whole
of the sea to the north were converted into dry and large parts of the sediments underwent the most intense disturbances to form the mighty ranges of the Himalayas and their neighbours.

During the deposition of sediments, there were opportunities for the organic matter to decompose, to form petroleum. As a result traces of oil or gas is found in the Extra peninsular areas. Petroleum occurs also in the foothill region of the Naga Hills which lies south-east of the Upper Assam Valley.

In India petroliferous deposits of Tertiary age are also found in the north western areas of the peninsula, in Kutch and Saurashtra and the adjacent parts of Gulf of Cambay and Bombay. Sediments of the eastern plain and its offshore areas also contain petroleum deposits.

**Petroliferous Basins of India**

A map of sedimentary basins for exploration of petroleum in India was drawn up by Geological Survey of India during 1955, when the Government of India decided to take up oil exploration in the Public sector. During the last 25 years a great deal of exploration has been carried out. A large volume of data from geological, geophysical and
drilling investigations has been collected in many of the basins. Geologists have identified twenty six sedimentary basins in India (Fig. 1).

The petroleum basins of India are of diverse geological character and cover an aggregate area of nearly 1.8 million sq. km. of which the offshore basins around the Indian coasts account for nearly 0.4 million sq. km. The basins have been grouped under four categories namely,

1) Proved basins with commercial productions.
2) Basins with known occurrence of oil and gas, whose commercial production is yet to be established.
3) Basins with no significant oil and gas but geologically considered prospective, and
4) Basins with uncertain prospects.

Total prognosticated reserves of oil and oil equivalent gas are estimated to be 16.6 million tonnes, of which about 3.8 million tonnes have already been established by drilling. The proved recoverable reserves are estimated to be 510.8 million tonnes of oil and 478 billion cubic metres of gas.

The first category comprises three basins namely (i) Assam Shelf areas (ii) Cambay basin and (iii) Bombay offshore.
Fig. 1
**Assam Shelf Area**

It is a relatively stable region, forming a north-eastern prolongation of the Indian Peninsular shield. The Assam Shelf has an extension of nearly 40,000 sq. km. A total thickness of 7000 meter covers the basement Archeans. The main oil producing formations are the Barails (Oligocene) and also to some extent Tipam (Miocene).

Over 6,60,000 wells have been drilled and the principal oil producing fields are the Naharkatiya, Tengakhat, Moran, Jorjan, and Rudrasagar in the north-east part of the shelf. The Lakwa, Galeki and Boroholla are in the south-west part. Naharkatiya is the major field. It is interesting to note that at Tengakhat, north-east of Boroholla (near Jorhat) Oil is found in Paleocene/Eocene age sediments. In the latter locality oil is found also in the weathered and jointed basement granite. The oldest oil mine of the country Digboi is situated here. It is situated on an anticline adjacent to the Naga hills. The prognosticated reserves in the Assam-Arakan region is 859 million tonnes.

The total oil production rate at present in this region is only of the order of 3 million tonnes to 4 million tonnes per annum.
**Cambay Basin**

The basin extends from the Cambay Gulf northwards along a narrow tract upto Kutch and southwards to a little extent on the eastern and western sides of the Gulf. This is a rift basin and sediments overlie the trap basement highs. The sediments consist of both Paleogene and Neogene sequence and most of the oil is in the lower and middle part of this sequence. These Paleocene and lower Eocene sediments are 500 to 1500 metre thick.

So far 15 oil and gas fields have been discovered, though the production from most of these is rather small. However, the Ankleshwar oil field, discovered in 1960 to the east of the Gulf, proved to be a giant field. This field is yielding a production of nearly 4 million tonnes per annum. The oil from Ankleshwar oil is light and good in quality.

**Bombay Offshore**

It is a southern extension of the Cambay Basin and is in a broad shelf which is perhaps the longest continental terrace in the world. The oil fields of Bombay lie 160 km. west of Bombay. The area is covered by the Arabian sea to a depth of about 75 metres. The Bombay High giant field was initially discovered by seismic surveys carried out with the help of the Soviet team. Today this has proved to be the
most prolific field, producing nearly 25 million tonnes of oil and gas per annum.

The entire shelf from the coast towards the deep sea margin is segmented by basement controlled faults giving rise to many horst-graben features. The main oil and gas bearing formations are the carbonates (Tertiary). The Tertiary sediments in this basin are in places more than 5000 metres thick. The limestones are of Oligocene and Middle Miocene age. The main producing horizon of limestone is of middle Miocene age. There are several structures mostly anticlinal. The major fields of Bombay are Panna, South Bassein, Heera and Ratna, discovered at the end of 1983. The proved reserves of oil and oil equivalent gas in the Bombay offshore basin is around 2600 million tonnes, approximately two third of the total of such reserves in all basins taken together. The size of the offshore basin ranges from 1.75 to 38 sq. km. This basin is producing light oil as compared to the other thick oils of the Cambay and Assam basin.

The Bombay High production along with other inland fields contribute nearly 70% of India's total production of oil.

In the second category there are eight basins namely, i) The Krishna Godavari basin, ii) The Cauvery basin,

**Krishna-Godavari Basin**

This basin covers an area of about 20,000 sq. km. on land and 39,000 sq. km. offshore along the east coast of India (Fig. 2). Exposures of Pre-Cambrian rocks limit the basin from the west and north west. Towards the east, the basin extends offshore into the Bay of Bengal. The Krishna Godavari basin is a pericratonic basin formed along a divergent continental margin sediments and volcanic materials associated with initial rifting, were covered by post rift clastics and platform type carbonates and finally by a delta system. Several north-east south-west trending tectonic elements have been recognised within the basin. Onshore, the earliest exposed sediments consist of late Permian conglomerate sandstones. These are overlain by an early Cretaceous to Recent sequence of volcanics and sediments. The sequence penetrated by drilled wells consists of late Cretaceous claystones, overlain by thin volcanic flows of Cretaceous – Paleocene age. These are in turn overlain by a Paleocene and Eocene sequence of sandstone, shale and occasional limestones and by a Miocene to Recent sequence of
KRISHNA-GODAVARI BASIN

BAY OF BENGAL

Fig: 2
### STRATIGRAPHIC SEQUENCE OF KRISHNA BASIN

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- Sandstone
- Limestone
- Gas
- Clay/Shale
- Basalt
- Oil
- Siltstone
- Basement

*Fig: 3*
sands and clays (Fig. 3). In the offshore region, the sedimentary sequence encountered is Cretaceous to Recent in age and is comprised of over 3000 meter of sandstone siltstones, limestones, shales and clays.

Several gas accumulations (some associated with oil) have been discovered within sandstones, limestones, and fractured volcanics of Cretaceous and Palaeogene age in the onshore region. Offshore accumulations of oil and gas have been discovered within Miocene and Pliocene sandstones.

Cauvery Basin

This is one of the largest sedimentary basins of the east coast of India. Onshore, it covers an area of about 35,000 sq. km. and extends north wards from the southern tip of India upto Pondicherry (Fig. 4).

The western limit of the basin is formed by the exposures of Archean rocks. The tectonic features are aligned North-east - South-west and the basement has a horst-graben morphology resulting from faults with considerable displacements. Several tectonic zones have been recognised in this basin, many of these continue offshore to the east and south-east.
CAUVERY AND PALAR BASIN

Fig: 4
The Cauveri Basin came into existence during the early Mesozoic. Archean gneisses form the basement. Onland the exposed Phanerozoic sequence consists of continental sediments of late Jurassic to early Cretaceous age overlain by a marine sequence of late Cretaceous to Paleocene sediments and finally by Mio-Pliocene, continental sediments. The observed sequence contains several unconformities.

The sedimentary sequence encountered offshore is more continuous. The Cretaceous sequence contains mature source rocks in most of the sub-basins present. A number of wells have been drilled in the basin and accumulations of oil have been encountered within reservoir rocks of Eocene, Paleocene and Cretaceous age as well as within fractured basement.

**Mahanadi Basin**

The Mahanadi basin occupies an area of over 50,000 sq. km. and is situated along the east cost of India in the Mahanadi delta area, and in the adjacent offshore region (Fig. 5). This basin was formed at one of the many triple junctions that existed along the east coast of India during the break-up of Gondwanaland. Onshore, the extent of the basin is limited by outcrops of Pre-Cambrian rocks. Offshore, the basin is bounded on the south west by a basement high occurring near the southern and of lake Chilka, towards north-east, it is continuous with the Bengal basin.
Tectonically, the Mahanadi basin can be divided into four distinct zones from northwest to the southeast. These zones are, a zone with almost linear ridges and depressions, a zone with southeasterly dipping basement affected primarily by down-to-basin faults, a hinge zone straddling the Eocene shelf margin and zone of growth faults and related structures.

Onland, the outcrops of Phanerozoic sedimentary rocks comprise of sandstones of upper Jurassic to lower Cretaceous age and limestones and claystones of Miocene age. Though extensive seismic surveys have been carried out, no wells have been drilled in this region till date.

A number of wells have been drilled in the offshore part of the basin. The rocks encountered in the subsurface consist primarily of a Cretaceous volcanic sequence with interlayered clastic sediments, a Lower Tertiary carbonate sequence with interbedded clastic sediments and upper Tertiary clastic sequence.

Mature source rocks are present within the Mio-Pliocene sediments of the region east of the Eocene shelf margin and within the Eocene and older sequence of the region, west of it. Also good reservoir rocks (porous sandstones and carbonates) and adequate cap rocks are present within the sequence penetrated by all the wells.
Bengal Basin

This basin covers most of West Bengal and extends over Bangladesh. The large tract extends for 90,000 sq.km. Sediments range in age from lower Gandwana to Recent. Several wells drilled under the Indo-Stanvac Project in the fifties encountered Eocene limestone and at depth Rajmahal Trap.

Tripura-Cachar-Mizoram

In this region, mainly geosyclinal Neogene sediments are found on the surface and subsurface. Gas shows at several localities in Tripura-Mizoram areas and in Cachar, oil has been located. The structure consist of a series of anticlines close together with synclines in between. Due to logistic difficulties in this hilly tract estimation of reserves is not done yet.

Andaman-Nicobar Islands

The inland and offshore areas have an aggregate area of 30,000 sq. km. The sediments comprise of Oligocene and the older formations are Mesozoic. The Port Blair formation is of Oligocene as in the offshore of Sumatra. The structure in the Andaman form a set of sharp folds at close intervals, whereas in Nicobar the structures open out considerably. Four deep wells have been drilled in the offshore areas on either side of Andaman while one of the wells encountered
gas, in the carbonate section of Miocene, while the other proved to be dry. (Plate 1).

**Jaisalmer**

In the Jaisalmer basin, small accumulation of gas has been found by drilling in the shelf area at Manhera Tibba in Eocene limestone. The deeper geosynclinal portions of the basins at Krishnagarh may be prospective of oil or gas. The logistic problems connected with the desert area riddled with sandstones have to be overcome. (Plate 2).

**Himalayan Foot Hills on the North**

In the Himalayan foot hills of Punjab indications of gas have been found at Jwalamukhi and a few other localities. The drilling of the Jwalamukhi well in the Siwalik showed appreciable quantities of gas at a depth of 600 metres in Lower Siwaliks. However, in the area adjoining this well failed to establish any gas reserves. A well drilled on the Janauri-Siwalik anticline north of Hoshiarpur encountered basement at 5000 metres without coming across with the Eocene sediments.

In the third category are 4 basins namely, i) Bikanir Nagaur in Rajasthan ii) Kutch iii) Saurashtra, iv) Kerala and v) Lakshadweep on the west coast.
Plate -1
Offshore oil drilling in Andaman
Plate - 2
Drilling in Rajasthan
**The Bikanir-Nagpur Basin**

It is 30,000 sq. km. in extent and the sediments are mainly PreCambrian to Paleozoic with some Tertiary. However, Mesozoic is absent as it is evident from a well at Pugal. The petroleum prospect is meagre.

**Saurashtra Basin**

Saurashtra Basin is located on the west coast of India immediately north of the prolific oil bearing Bombay offshore (Fig. 6). The total area of the basin is approximately 38,000 sq. km.

The structures in this area are influenced by NNW-SSE Dharwar trend as well as the ENE-WSW Satpura trend. A thin veneer of Tertiary outcrops fringe the western and southern coast line of the Saurashtra Peninsula east of which a Paleocene-Cretaceous basalt flows (the Deccan Trap) are exposed together with a Cretaceous sandstone in the northwest corner.

Three wells drilled in the southern part of the basin encountered rocks ranging in age from Paleocene to Recent. In the shelf part a complete Tertiary sequence was encountered in one well. The sediments are carbonate rich. However, beyond the paleo-shelf margin, a huge thickness of finer clastics of Miocene-Pliocene age were encountered. In a recent
well drilled in the southern part of the basin, some hydrocarbons were observed during drilling through sediments ranging from Paleocene to Miocene. Oil has been discovered in Eocene sediments in one of the wells in the Kutch offshore basin. The potentially prospective Mesozoic rocks have so far not been penetrated in any of the wells drilled.

**The Konkon-Kerala Basin**

This basin lies to the south of Bombay offshore basin (Fig. 7) and is separated from it by an east west trending basement arch. It covers an area of about 210,000 sq. km. along the western continental shelf of India.

The northern part of the basin (north of Calicut) is referred to as the Konkon basin while the southern part is known as the Kerala basin. Development of this basin was initiated during the Cretaceous with a series of NNW-SSE trending step faults down thrown towards the west. Except over the basement highs there is a gradual increase in thickness of the younger strata west wards. Onland outcrops of Miocene sands, clays and lignite occur as discontinuous patches bordering the shield area.

Three wells have been drilled in the basin. One well drilled near the coast penetrated a Tertiary sequence comprising mostly of quartzose sandstones and claystones overlaying
a Cretaceous sequence of basaltic flows and interbedded clastic sediments.

The sequence in a well, drilled near the shelf margin in the northern part of the basin consists of dolomitic limestones, Eocene to Miocene in age, overlain by Plio-Pleistocene and Recent days deposits.

Lakshadweep

The Lakshadweep islands located off the Kerala coast form a part of the Chagos Lakshadweep ridge. Regional seismic data indicate that sediments on the ridge are Paleocene and Lower Eocene in age and are capped by Holocene coral reefs. In the depression to the east and on the flank of the ridges, a complete sequence of Tertiary sediments appear to be present.

In the fourth category 8 basins are listed.

The Ganga valley covers 3,00,000 sq. km. and is an alluvial tract adjoining Siwalik foot hills. Below the alluvium, Siwalik and Vidhyan sediments have been met with unconformity. The Vidhyans have revealed many anticlinal and
synclinal structures and faults, whereas Siwalik sediments have monotonous homoclinal feature increasing in thickness gradually towards the foot hills.

Most of the wells drilled are at or near the apex of the subsurface, anticlinal structures. The flanks of such structures must also be drilled since fluid movements may be such as to trap hydrocarbons on the flanks.

References

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