BOOK REVIEW

PETROLIFEROUS BASINS OF INDIA, edited by the K. D. Malaviya Institute of Petroleum Exploration, Oil and Natural Gas Commission; Publishers: Petroleum Asia Journal; p. 159; 1983; Price: Rs. 200; US $ 50.

A map of the sedimentary basins for exploration of petroleum in India was drawn up in the Geological Survey of India during 1955, when the Government of India decided that oil exploration be taken up in the public sector. Later, the late A. M. N. Ghosh, then Member, O. N. G. C., presented a paper on 'Sedimentary Basins of India' at the Economic Conference on the Petroleum Resources of Asia and Far East (ECAFE) held in New Delhi in 1958. At that time the information was little. 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. Remarkable success has been achieved by the discovery of many commercially productive oil and gas deposits. It is, therefore, appropriate and timely that a comprehensive publication has been brought out on the Petroliferous Basins of India by the K. D. Malaviya Institute of Petroleum Exploration.

The Petroliferous Basins of India are of diverse geological character and extend over an aggregate area of nearly 1.8 million km², of which the offshore basins around the Indian coasts account for nearly 0.4 m. km². In all, 23 basins have been dealt with in 15 papers, by one or more authors. The papers deal in detail with the geologic and stratigraphic features of the basins, and also furnish the geophysical and well data with petroleum prospects.

In a review to be of tolerable length, it is out of question to review the papers individually. However, the hydrocarbon prospects of the basins, touching incidentally on their main geological characters, will be presented.

The basins have been grouped under four categories, viz., (1) Proved basins with commercial production, (2) Basins with known occurrences 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. A map of India showing these categories in colour has been presented.

The first category comprises three basins, viz., (i) Assam shelf area, (ii) Cambay Basin and (iii) Bombay offshore.

Assam shelf area

The Assam Shelf is the relatively stable region, forming a N. E. prolongation of the Indian Peninsular Shield. The Assam shelf has an extent of nearly 40,000 km². It is mainly covered by the Brahmaputra alluvium. A total thickness of 7000 m sediments cover the basement Archaean. The main oil producing formations are the Barails (Oligocene) and also to some extent the Tipam (Miocene). Over 6,60,000 wells have been drilled and the principal oil producing fields are the Nahorkatiya (NHK), Tenghakhat, Moran, Jorjan and Rudrasagar in the N.E. part of the shelf. The Lakwa, Galeki and Boroholla are in the S.W. part. NHK is the major field. It is interesting to note that at Tenghakhat, N.E. of NHK, and Boroholla (near Jorhat), oil has been met in the Paleocene/Eocene. In the latter locality, oil is found also in the weathered and jointed basement granite. The prognosticated reserves in the Assam-Arakan region is 859 m tonnes. Actually, the total oil production rate at present in this region is only of the order of 3 m tonnes to 4 m tonnes per annum. It would thus be seen that more intensive exploration is indicated in order that production is increased considerably.
Cambay Basin

This first came into prominence after ONGC discovered oil near Cambay in 1958. This basin extends from the Cambay Gulf northwards along a narrow tract up to Kutch and southwards to a little extent on the eastern and western sides of the Gulf. The total extent is 56,000 km². This is a rift basin and sediments overlie the Deccan trap and structures are mostly over 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. The Paleocene to lower Eocene is 500 m to 1500 m thick. During the past 25 years, very extensive and detailed exploration has been carried out in this basin.

So far 54 oil and gas fields have been discovered, though the production from most of these is rather small. However, the Anklesvar oil field, discovered in 1960 to the east of the Gulf, proved to be a giant field. Upto now a total of nearly 50 m tonnes has been produced from this single field, yielding a production of nearly 4 m tonnes per annum in the peak productive period. The Anklesvar oil is light and of high quality. Although this basin has been intensively explored mostly by locating anticlinal structures, there seems to be yet some further scope in finding oil in the more subtle stratigraphic traps; possibly also in fluid traps to some extent.

Bombay Offshore

It is a southern extension of the Cambay basin and is in a broad shelf which is perhaps the largest continental terrace in the world. The oil fields of Bombay offshore lie 160 km off Bombay. The area is covered with water of the Arabian sea to a depth of about 75 m. 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, now producing nearly 25 m tonnes of oil and also a large quantity of 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 carbonate formations (Tertiary). The Tertiary sediments in this basin are in places more than 5000 m thick. The limestones are of Oligocene and middle Miocene age. The main producing horizon is in middle Miocene. There are several structures, mostly anticlinal. The major fields of the Bombay High are Panna, S. Bassein, Heera and Ratna, discovered to the end of 1983. The proved reserves of oil and oil equivalent gas in the Bombay offshore basin is around 2600 m tonnes, approximately amounting to 2/3rd of the total of such reserves in all the basins put together. The size of the oil fields of this offshore basin ranges from 1.75 km² to 38 km². This basin is producing light oil as compared to the rather thick oils of the Cambay (excepting that of Anklesvar field) and Assam basins.

At a time when the country was burdened with large imports of crude oil from abroad costing near about Rs. 6000 crores per annum in foreign exchange, the Bombay High production came as a great help to the nation. This, together with the other inland fields, contribute now nearly 70% of our total requirement of oil. Mention may also be made here of the production of a large quantity of LPG for domestic use from the gas in Bombay offshore and also that in NHK field of Assam.

In the second category, there are eight basins: (1) and (2) The Krishna-Godavari and the Cauvery, (3) The Mahanadi, (4) Bengal, (5) Tripura-Cachar, (6) Andaman-Nicobar on the East, (7) Jaisalmir, and (8) Himalayan Foot Hills on the North.

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Krishna-Godavari and Cauvery Basins

Oil and gas in appreciable quantities have been found in the wells drilled both on-shore and off-shore. It is hoped that commercial production will be established in these two basins in the near future. Exploration by ONGC is being pursued vigorously. These two basins have parallel and comparable geological history and both are characterized by Mesozoic and Tertiary sequence of large thickness. The Krishna and Godavari basins extend both on-land and off-shore for about 40,000 km². The Cauvery basin extends both on-shore and off-shore to a total of about 50,000 km². In both these basins, oil and gas have been found generally in anticlinal drapes above basement highs. In both, sand and limestone, have accumulations of oil and gas. In the Godavari-Krishna basin, 4,000,000 m³ per day gas has been found in a well near Narasapur and very promising oil sands in the off-shore belt near Machilipatnam in rather deeper waters of the Bay of Bengal from 100 m to 600 m depth. However, the development of oil reserves in this off-shore has difficult drilling problems. ONGC has been tackling these effectively.

In the Cauvery basin, oil has been found near Karaikal inland and Porto Novo and Palk Bay in offshore. In the Porto Novo well, oil and gas horizons are in Paleocene and Eocene, whereas in the Palk Bay oil has been found in the Mesozoic. Oil has been found in upper Cretaceous sandstone. There are still some difficulties in establishing adequate reserves in both the Krishna-Godavari and Cauvery basins, but they are being tackled effectively.

Mahanadi Basin

In the Mahanadi Basin, Oil India Ltd are carrying out exploration on land and off-shore. Together the extent is 20,000 km²; off-shore alone is as much as 12,000 km². The data collected show that this is a pull apart basin closely parallel to the coast. Some structural closures have been outlined and two wells have been drilled offshore. Here also some drilling difficulties are met and Oil India Ltd are tackling them effectively. In these wells, indications of hydrocarbons have been found and further exploration is in progress.

Bengal Basin

This basin covers most of West Bengal and extends over Bangladesh. The large tract extends for 90,000 km². Sediments range in age from lower Gondwana to Recent. The Neogenes thicken considerably in the eastern part due to large scale delta building activity initiated during Himalayan Orogeny. Several wells drilled under the Indo-Stanvac Project in the fifties encountered Eocene limestone and at depth, Rajmahal trap. Some minor indications of oil and gas were met, but nothing of consequence. Later ONGC drilled a deep well at Bodra further south and a few more at other localities, but beyond getting some indications of gas, no economical accumulations were discovered. In the off-shore a foreign private company drilled two wells and here again, no appreciable hydrocarbons were found. However, in such a vast basin with so large a thickness of sediments favourable for generation and accumulations of hydrocarbons, one has to persevere for some more time. Reefoidal limestones located off-shore need also to be explored in detail.

Tripura-Cachar-Mizoram

In this region, mainly geosynclinal molasses Neogene sediments are found on the surface and sub-surface. Gas shows at several localities in Tripura-Mizoram.
areas; and in Cachar oil is found. The structures consist of a series of anticlines close together with synclines in between. Drilling in Tripura has shown fairly large quantities of gas. The estimation of reserves would involve drilling a large number of wells, but owing to logistic difficulties in these hilly tracts the progress is slow.

Andaman-Nicobar Islands

The inland and offshore areas have an aggregate area of 30,000 km$^2$. The sediments comprise of Palaeogene, and the older formations are Mesozoic. The Port Blair formation is of Oligocene as in the offshore of Sumatra. The structures in the Andaman form a set of sharp folds at close intervals, whereas in the Nicobar islands 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, the others proved to be dry. Commercial potential of the gas deposit remains yet to be established.

Jaisalmir

In the Jaisalmir basin, small accumulation of gas has been found by drilling in the shelf part at Manhera Tibba in Eocene limestone. The deeper geosynclinal portions of the basins at Shahgarh and Krishnagarh may be prospective of oil/gas. Substantial progress in exploration here is yet to be made. The logistics problem connected with this desert area riddled with sand dunes have to be overcome.

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 Siwaliks showed appreciable quantities of gas in the first well drilled in 1957 by ONGC at a depth of 600 m in lower Siwaliks. However, in the area adjoining this well, drilling failed to establish any gas reserves. A well drilled on the Janauri Siwalik Anticline north of Hoshiarpur encountered basement at 5000 m without meeting Eocene. Yet another deep well was drilled at Surinmastagarh further west in the Siwaliks, but before the well could be completed, to the projected depth, it had to be given up owing to high pressure encountered.

In the third category are four basins: (1) Bikanir-Nagaur in Rajasthan, and (2) Kutch, (3) Saurashtra, (4) Kerala, (5) Lakshadweep on the west coast.

(1) The Bikanir-Nagaur basin is 36,000 km$^2$ in extent and the sediments are mainly Precambrian to Palaeozoic with some Tertiary. However, Mesozoic is absent as evidenced from a well at Pugal. The petroleum prospects are somewhat meagre.

Regarding (2), (3) and (4), the Kutch and Saurashtra offshore areas have been taken up by foreign companies for exploration. While in Kutch portion two wells have been drilled showing no commercial hydrocarbons, in the Saurashtra offshore a well is proposed to be drilled shortly. Further south, the Konkan offshore adjoins the Bombay offshore fields and the prospects here are considered bright. In Kerala offshore, one well was drilled off Cochin by ONGC. No hydrocarbon indications were met. However, drilling in the deeper parts further offshore may show good prospects.

Coming now to the fourth category, eight basins have been listed: (1) Arunachal foot hills, (2) Ganga valley, (3) Deccan syncline, (4) Karewa (Kashmir valley), (5) Mizoram-Manipur, (6) Narmada, (7) Gondwana, and (8) Vindhyan.

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Of the above, only the Ganga valley and Vindhyan will be reviewed here together, though the other basins too may be important and need detailed exploration. The reason for considering Ganga valley and Vindhyan together is that the latter formations occur extensively in the subsurface of the former. Moreover, Ganga valley which covers an area of 300,000 km² has been investigated extensively by geophysical surveys and deep drilling at a few locations.

The Ganga valley is an alluvial tract adjoining the Siwalik foot hills and extends to the margin of the southern shield. Test wells have been drilled at Ujhani, Tilhar and Puranpur and also at Rauxal in the Gandak depression and at Purnea in Bihar. Below the alluvium, Siwalik and Vindhyan sediments have been met with a profound unconformity between the latter two. The Vindhyan have revealed many anticlinal and synclinal structures and faults, whereas Siwalik sediments have a monotonous homoclinal feature increasing in thickness gradually towards the foothills. In the Tilhar well, a little gas is said to have been indicated, whereas in the other two wells no indications of hydrocarbons have been reported. In the Rauxal well, Siwalik formations overlie the Mesozoic, which in turn, is overlain by Vindhyan and finally the Archaean basement. In the Purnea well, Gondwana formations were encountered with thick coal beds.

The reviewer considers that greater attention should be paid in further detailed exploration since all the seismic reflections below the Siwaliks and above Vindhyan have not been clearly identified and followed up.

Further, the Lower Siwaliks have considerable salinity in the electrologs, wherever they have been arrived, as in the Jwalamukhi well, the Adampur well (near Jalandhar) and also in the other wells in Uttar Pradesh and Rauxal. Most of the wells drilled are at or near the apex of the subsurface anticlinal structures in the Vindhyan. It is advisable in drilling further wells, the flanks of such structures should also be drilled since fluid movements may be such as to trap hydrocarbons on the flanks. The writer had drawn attention to these aspects more than a decade back (this Journal, vol. 14, No. 3, 1973, pp. 238-240), but apparently no attention seems to have been paid.

Regarding the exposed Vindhyan, the rocks for the most part appear unfavourable for hydrocarbon accumulations. However, the Vindhyan of the Sone Valley contain coaly and carbonaceous shales with some primitive fossils (ibid). When such formations come under thick cover in the Ganga Valley, the possibility of finding oil or gas accumulations can increase.

To sum up our present position, commercial oil and gas deposits have been discovered in the Assam, Cambay offshore basins and are being exploited. In respect of established reserves of oil (and oil equivalent of gas), it is of the order of 4 billion tonnes. The recoverable reserves estimated at present amounts to one billion tonnes. For a country like ours where petroleum requirements are ever on the increase, there is no scope for complacency and vigorous exploration and development have to be continued both on-land and off-shore.

The get-up of the book is good, but the small types used for printing makes reading difficult. A few misprints have been noticed. Most of the maps and diagrams have been reproduced in such poor manner that it is almost impossible to read them. It is hoped that there will be a future edition, as the contents are of great interest not only to those interested in petroleum but also to Geoscientists for the wealth of geological and geophysical data presented.

M. B. RAMACHANDRA RAO