

## PETROLEUM GEOLOGY AND HYDROCARBON PROSPECTS OF SINDH, PAKISTAN

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### Abstract

The province of Sindh is situated in the Lower Indus Basin and includes the Sukkur Rift Zone, Sindh Monocline, a part of Khirthar Depression, Karachi Depression, Mazarani Fold Zone and a part of Khirthar Fold Zone. It fulfills all the requirements of generation and accumulation of Petroleum. Presently Sindh is a major producer of oil and gas. About 40 oilfields and 30 gasfields have been discovered in Sindh, out of which 30 oilfields and 12 gasfields are on production. So far Sindh Monocline is the only oil producing region of Sindh. Karachi Depression and Sukkur Rift Zone are gas producing regions. With the discovery of new gasfields in Sukkur Rift Zone, this region will be a major gas producer in future.

Due to non availability of sufficient refining facilities, the daily production of oil cannot be increased. It is hoped that with the installation of new refinery at Badin, the production of oil will increase in future.

### Introduction

Pakistan contains two sedimentary basins, the Indus Basin and the Baluchistan Basin. These basins, separated by a major fracture zone, the axial belt, collectively occupy an area of about 828,000 square kilometers. The Indus Basin is an extensively explored area and is the only basin, so far, from where oil and gas is produced.

The Indus Basin is divided into large longitudinally oriented parallel tectonic features which are further subdivided by sub-longitudinal basement highs and transverse uplifts, into smaller tectonic zones.

The main tectonic features of the Indus Basin are the platform, the foredeep comprising depressions, an inner folded zone and the outer folded zone. The platform, known as the Indian Platform, coincides with the present Indus Plain and is sub-divided into the Punjab Monocline, Sukkur Rift and Sindh Monocline. The foredeep includes, from north to south, the Potwar, Kohat, Sulaiman, Sibi, Khirthar and Karachi Depressions. The inner

folded zone includes Zinda Pir, Mari-Bugti and Mazarani where as the outer folded zones are Sulaiman and Khirthar Fold Zones.

The province of Sindh is situated in the Lower Indus Basin and includes the Sukkur Rift Zone which comprises of Kandhkot-Mari Horst, Panno Aqil Graben and Jacobabad - Khairpur Horst, Sindh Monocline, a part of Khirthar Depression, Karachi Depression, Mazarani Fold Zone and a part of Khirthar Fold Zone (Fig. 1). It fulfills all the requirements of generation and accumulation of hydrocarbons. Presently Sindh is a major producer of oil and gas where about 40 oilfields and 30 gasfields have been discovered, out of which 30 oilfields and 12 gasfields are on production with average daily production of 32893 barrels of oil and 641 mmcf of gas. This makes 56% oil and 37% gas of country's daily production.

The stratigraphy, tectonics and petroleum geology of the area has been described by many authors like Rizvi et al., (1972), Abid and Siddiqui (1984), Quadri and Shuaib (1986), Chaudry M. (1981), Malik et al., (1988), Raza et al. (1990, 1992), Arif Kemal et al., (1992) and Hussain et al., (1992).

The present paper is an over-view and synthesis of the literature. The latest available data of petroleum and gas production are given.

### **Search For Oil**

The first well in Sindh was drilled in Khairpur by Burmah Oil Company in 1925, with no success. After independence the pace of exploration of oil accelerated. With the discovery of Sui gasfield in Balochistan in 1952, the northern Sindh was main area of exploration and gas was discovered by Pakistan Petroleum Limited in Khairpur (1957), Kandhkot (1959) and Mazarani (1959). At the same time Stanvoc Oil Company (SVOC) discovered Mari gasfield in 1957. This company later became Esso Co. Presently Mari gasfield is owned and operated by Mari Gas Co. Ltd. (MGCL). SVOC also drilled wells in Talhar (1957), Mirpur Bathoro (1958), Nabisar (1958) and Badin. Nabisar showed some gas while Talhar showed oil and gas. Burmah Oil Company (BOC) and Hunt Oil Company drilled wells at Lakhra (1958), Badhra (1958-59) and Phulji (1958). These wells only showed some gas. In the year 1961, Oil and Gas Development Corporation (OGDC) was established. They discovered gas at Sarisingh (1966), Kothar (1973) and Hundi (1977).

In sixties the coastal area of Sindh also witnessed exploration activities. Sun Oil Company drilled wells at Korangi Creek (1965), Patiani Creek (1964) and Dabbo Creek (1964) with no success. All these wells were onshore.

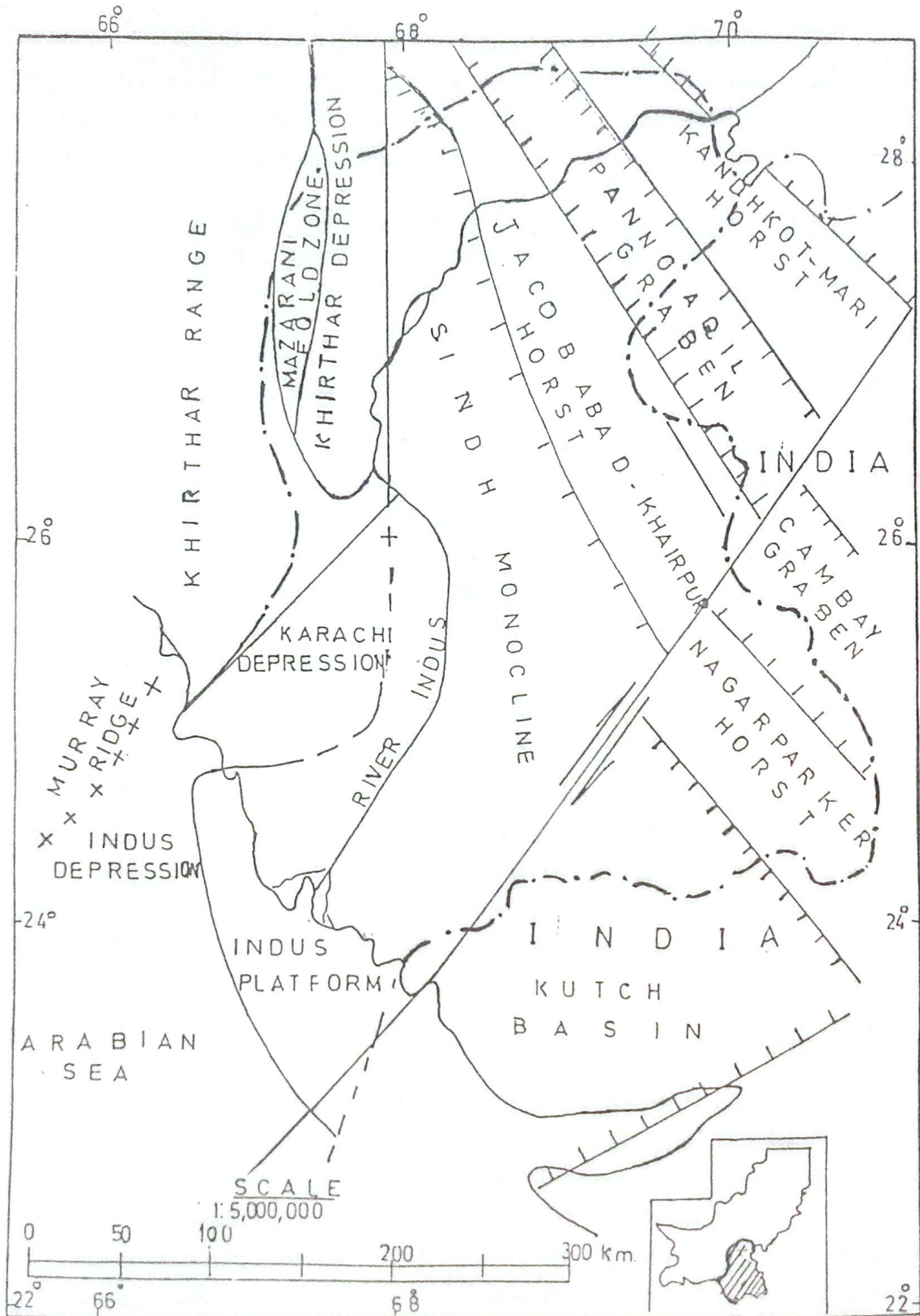


Fig. 1. Tectonic Map of Lower Indus Basin (after Raza et al. 1990) showing the location of Sindh there-in.

The discovery of Khaskheli Oilfield in 1981 was an important event which disproved all the previous notions about this region which was considered as gas prone. Since then the area has become important from exploration point of view and a large number of oil and gas fields have been discovered.

Recent discovery of gas in Qadirpur (1990), Badar (1994), Kandhra (1990), Miano (1993), Kandanwari (1989) and Gorwar (1991) in Sukkur Rift Zone has increased interest and it is hoped that the area will soon become a major gas producer.

### **Tectonics**

In global tectonic perspective, Pakistan is situated at the junction of three lithospheric plates, the Indian Plate, Arabian Plate and Eurasian Plate. The Indus Basin is situated on the north-western corner of the Indian Plate (Fig. 2). The Indian Plate after separating from the African Plate during Jurassic-Early Cretaceous started drifting in the north-eastern direction and collided with the Eurasian Plate in Paleocene-Early Eocene (Malik 1988). The collision is characterised by continent to continent collision, obduction and thrusting and is considered the prototype Alpine-Himalayan orogen. The mountain belts in Pakistan are the result of these episodes.

During Lower to Middle Cretaceous the southern part of the Indus Basin was subjected to extensional tectonic and block-faulting occurred, followed by volcanic activity (Deccan Trap Volcanics) as witnessed in the Southern Sindh in Pakistan and Cambay region in India (Malik et al., 1988). Thus these two main events have greatly affected and modified the tectonics of the basin.

### **Stratigraphy**

Excepting Pre-Cambrian granites exposed in south-eastern corner at Nagar Parkar in Tharparkar District and some volcanic trap rocks (Paleocene) in Baro Nalo Amri, the rocks in Sindh are sedimentary averaging in thickness of 5000 m, with a maximum of 10,000m, and belong to Mesozoic to Recent in age. The sediments are thinner eastward on the platform while their thickness is increasing towards west and is maximum in the foredeep. All the members of the Tertiary period are well developed and form the Khirthar

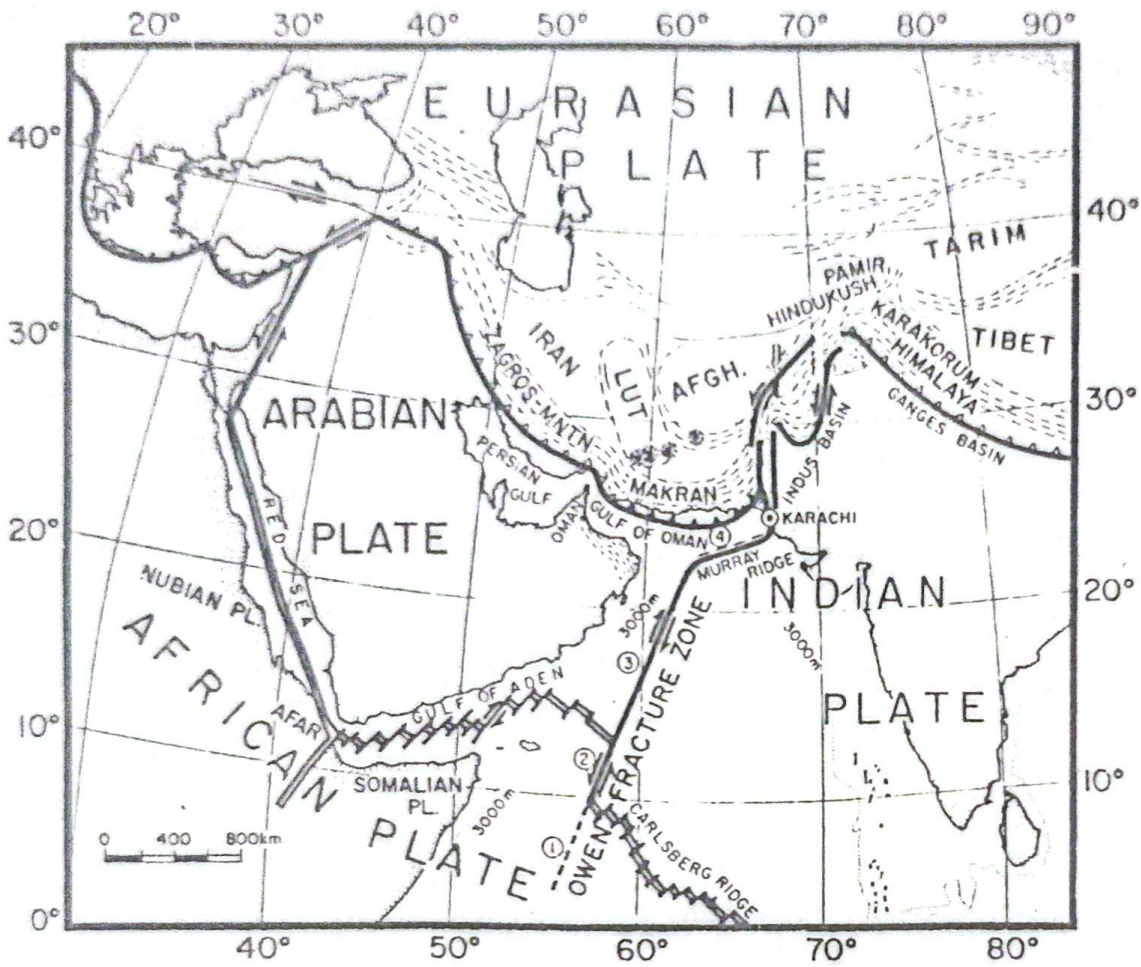


Fig. 2. Plate Tectonic map of the Middle East showing location of the Indus Basin (after Jacob and Quittmeyer 1979).

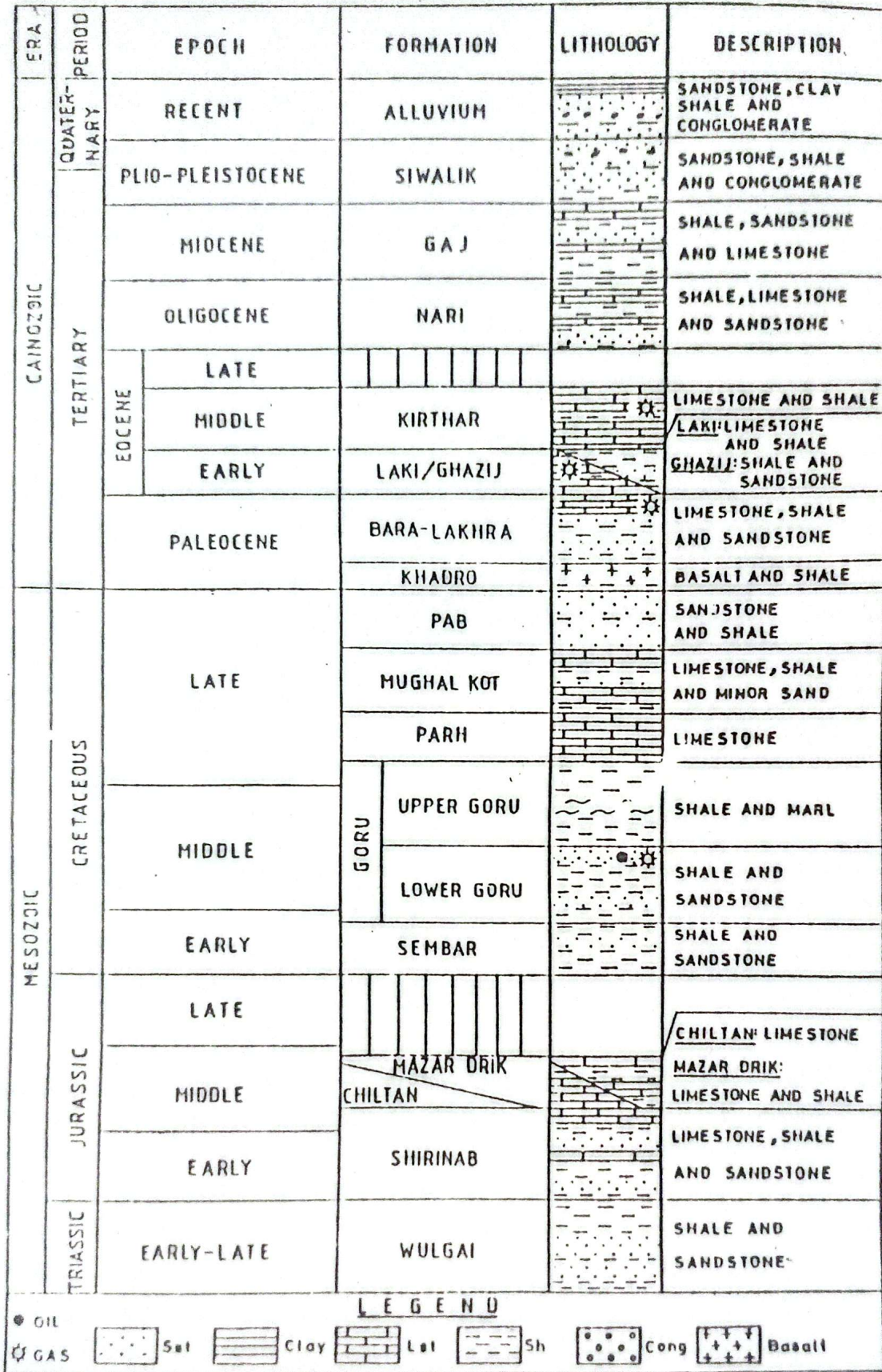


Fig. 3. Generalized Stratigraphy of the Lower Indus Basin (after Raza et al. 1990).

and Laki Ranges of Sindh. The rest of Sindh is covered by alluvium with exception of Ganjo Takar, Kot Diji and Rohri where limestones of Eocene are exposed. Triassic to Tertiary rocks overlain by thick alluvium have been drilled in the platform region.

The stratigraphy of the Lower Indus Basin (Fig. 3) is as follows:  
The Triassic rocks comprise shales and sandstones.

The Jurassic rocks consist of shallow marine limestone in the upper part and clastics (sandstone and shales) in the lower part.

The Cretaceous sediments range from shales deposited in deep depressions which in turn are overlain by shallow marine limestones and thick sandstones in the upper part.

The Paleocene rocks are mostly shallow water clastics overlain by limestones. At some places basalts are present in the lower part of Paleocene.

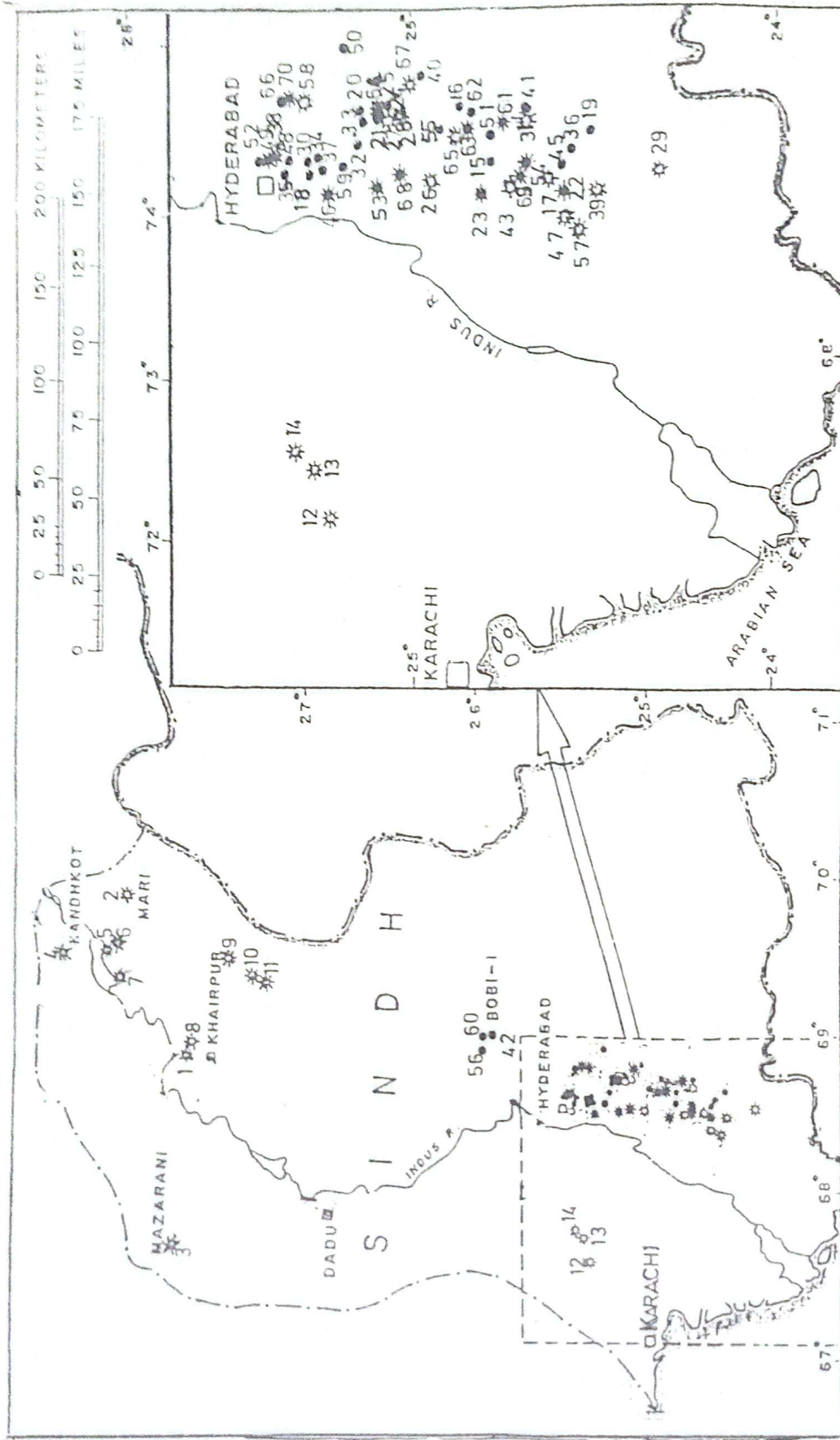
The Eocene strata comprise of shales and limestones. Oligocene rocks are limestones, shales and sandstones. Miocene rocks consist dominantly of shale, limestone and sandstones.

Plio-Pliocene rocks consist of coarse to fine grained clastics.

### **Petroleum Prospects**

For commercial accumulation of hydrocarbons in any area, five parameters are required, 1) a source rock which is generally fine grained clay containing over 0.5% organic matter (Kerogen) by weight, 2) a porous and permeable reservoir rock to hold hydrocarbons, 3) an impermeable seal or cap rock to prevent upward escape of hydrocarbons from the reservoir, 4) a trap which is right geometrical arrangement of source, reservoir and seal and 5) right geothermal temperatures to generate oil (greater than 60°C) or gas (greater than 160°C).

The Indus Basin fulfills all these requirements of generation and accumulation of oil and gas. Petroleum prospects of Sindh are described according to its main tectonic zones i.e. the Sukkur Rift Zone, Mazarani Fold Zone, Karachi Depression and Sindh Monocline. A complete list of Oil and Gas fields in each zone is shown in Figure 4 and Table 1.



**LEGEND**

OIL FIELD

1. Khairpur	15. Khaskheli	29. Jabo	43. Khorewah-1	57. Hoor-1
2. Mari	16. Laghari	30. Ghotana	44. Imhra-1	58. Buzdar-1
3. Mazarani	17. Golarchi	31. Makhdoompur	45. N. Akri-1	59. Mian Ismail -1
4. Kandhkot	18. Tando Alam	32. Liari	46. Daru-1	60. Bobi North-1
5. Qadirpur	19. Tajedi	33. Halipota	47. Bagla-1	61. Mahi-1
6. Qadirpur X-2	20. Mazari	34. South Lashari	48. Thora East-1	62. Bari-2
7. Badar	21. Dabhi	35. Thora	49. Kunar-1A	63. Bachal-1
8. Kandra	22. Nari	36. Ghanghro	50. Tando Ghulam Ali	64. S. Mazari Deep-1
9. Miano	23. Turk	37. Sono	51. Koli-1	65. Jalal-1
10. Kandanwari	24. South Mazari	38. Kunar-2	52. Pasakhi-1	66. Buzdar South-1
11. Gorwar	25. Sonro	39. Pir-1	53. Kato-1	67. Buland-1
12. Sari Singh	26. Bukhari	40. Paniro-2	54. Bhatti-1	68. Zaur-1
13. Hundi	27. Dabhi South	41. Daphri-1	55. Rind-1	69. Nakurji-1
14. Kothar	28. Matli	42. Bobi-1	56. Dhamrakhi-1	70. Buzdar North-1

## OIL AND GAS FIELDS IN SINDH.

( AS ON FEBRUARY 1994 )

**Table 1**  
**Oil and Gas Fields in Sindh**

S.No.	Name	Year of Discovery	Tectonic Zone	Producing horizon	Status	Original Recoever-able Reserves mmbbl/tcf.*	Remarks
1.	Khairpur	1957	Sukkur Rift	Eocene L.St.	Gas	1.0	Dormant.
2.	Mari	1957	-do-	Eocene L.St.	Gas	4.043	Producing
3.	Mazarani	1959	Mazarani Fold zone	-do-	Gas	0.091	Dormant
4.	Kandhkot	1959	Sukkur Rift.	-do-	Gas	0.796	Producing
5.	Qadirpur	1990	-do-	-do-	Gas	3.978	Dormant
6.	Qadirpur X-2	1991	-do-	-do-	Gas	N.A.	-do-
7.	Badar	1994	-do-	-do-	Gas	N.A.	-do-
8.	Kandra	1990	-do-	-do-	Gas	N.A.	-do-
9.	Miano	1993	-do-	Cretaceous-sand	Gas	N.A.	-do-
10.	Kandanwari	1989	-do-	-do-	Gas	N.A.	-do-
11.	Gorwar	1991	-do-	-do-	Gas	N.A.	-do-
12.	Sarisingh	1966	Karachi-Depression	Paleocene-L.St.	[ Gas Gas	0.065	Producing
13.	Hundi	1977	-do-	-do-			
14.	Kothar	1973	-do-	-do-	Gas	0.017	Dormant
15.	Khaskheli	1981	Sindh Monocline	Cretaceous sand	Oil	7.572	Producing
16.	Laghari	1983	-do-	-do-	Oil	13.0	Producing
17.	Golarchi	1984	-do-	-do-	Gas	0.024	Producing
18.	Tando Alam	1984	-do-	-do-	Oil	9.378	Producing
19.	Tajedi	1984	-do-	-do-	Oil	0.215	Dormant
20.	Mazari	1984	-do-	-do-	Oil/Gas	9.772	Producing
21.	Dabhi	1984	-do-	-do-	Oil	3.166	Producing
22.	Nari	1985	-do-	-do-	Oil/Gas	0.285 0.019	Producing
23.	Turk	1985	-do-	-do-	Oil/Gas	0.197 0.060	Producing
24.	South Mazari	1985	-do-	-do-	Oil/Gas	2.161	Producing
25.	Sonro	1985	-do-	-do-	Gas	0.065	Dormant
26.	Bukhari	1985	-do-	-do-	Gas	N.A.	Producing
27.	Dabhi South	1986	-do-	-do-	Gas	0.004	Dormant
28.	Matli	1986	-do-	-do-	Gas	0.005	Producing
29.	Jabo	1986	-do-	-do-	Gas	0.003	Dormant
30.	Ghotana	1986	-do-	-do-	Oil	0.200	Dormant
31.	Makhdoompur	1986	-do-	-do-	Gas	0.016	Producing
32.	Liari	1986	-do-	-do-	Oil/Gas	0.854	Producing
33.	Halipota	1986	-do-	-do-	Oil/Gas	0.691	Producing
34.	South Lashari	1987	-do-	-do-	Oil	N.A.	Producing
35.	Thora	1987	-do-	-do-	Oil	4.220	Producing
36.	Ghanghro	1987	-do-	-do-	Oil	1.359	Producing
37.	Sono	1987	-do-	-do-	Oil	7.260	Producing

38.	Kunar-2	1988	-do-	-do-	Oil/Gas	8,600	Producing
39.	Pir-1	1988	-do-	-do-	Gas	N.A.	Dormant
40.	Paniro-2	1988	-do-	-do-	Oil	N.A.	Dormant
41.	Daphri-1	1988	-do-	-do-	Oil	N.A.	Dormant
42.	Bobi-1	1988	-do-	-do-	Oil	0.720	Depleted
43.	Khorewah-1	1988	-do-	-do-	Gas	N.A.	Producing
44.	Injra-1	1988	-do-	-do-	Oil	N.A.	Dormant
45.	N. Akri-1	1988	-do-	-do-	Oil/Gas	N.A.	Dormant
46.	Daru-1	1988	-do-	-do-	Gas	N.A.	Dormant
47.	Bagla-1	1988	-do-	-do-	Oil	N.A.	Producing
48.	Thora East-1	1988	-do-	-do-	Oil/Gas	N.A.	Producing
49.	Kunar-1A	1988	-do-	-do-	Oil	N.A.	Dormant
50.	Tande	1989	-do-	-do-			
	Ghulam Ali-1						
51.	Koli-1	1989	-do-	-do-	Oil	N.A.	Dormant
52.	Pasakhi-1	1989	-do-	-do-	Oil	N.A.	Producing
53.	Kato-1	1989	-do-	-do-	Oil/Gas	N.A.	Dormant
54.	Bhatti-1	1989	-do-	-do-	Oil	N.A.	Producing
55.	Rind-1	1989	-do-	-do-	Oil/Gas	N.A.	Dormant
56.	Dhamrakhi-1	1991	-do-	-do-	Oil	N.A.	Dormant
57.	Noor-1	1991	-do-	-do-	Gas	N.A.	Dormant
58.	Buzdar-1	1991	-do-	-do-	Gas	N.A.	Producing
59.	Mian Ismial-1	1991	-do-	-do-	Oil	N.A.	Dormant
60.	Bobi North-1	1991	-do-	-do-	Oil	N.A.	Dormant
61.	Mahi-1	1992	-do-	-do-	Gas	N.A.	Dormant
62.	Bari-2	1992	-do-	-do-	Oil	N.A.	Producing
63.	Bachal-1	1993	-do-	-do-	Oil/Gas	N.A.	Producing
64.	S.Mazari	1993	-do-	-do-	Oil/Gas	N.A.	Producing
	Deep-1						
65.	Jalal-1	1993	-do-	-do-	Gas	N.A.	Dormant
66.	Buzdar	1993	-do-	-do-	Oil	N.A.	Producing
	South-1						
67.	Buland-1	1993	-do-	-do-	Gas	N.A.	Dormant
68.	Zaur-1	1994	-do-	-do-	Oil/Gas	N.A.	Producing
69.	Nakurji-1	1992	-do-	-do-	Gas	N.A.	Dormant
70.	Buzdar-North	1993	-do-	-do-	Oil/Gas	N.A.	Producing

- Source:
1. Raza et. al. (1989) Petroleum Zones of Pakistan, Pakistan Journal of Hydrocarbon Research Vol: 2 (July 1989).
  2. PROGRESS, April 1994, Pakistan Petroleum Ltd, P.I.D.C. House Karachi.
  3. Economic Survey (1993-94), Govt: of Pakistan.
  4. 7th Five Year Plan (1988-93) Oil and Gas Development Corporation.

\*Million barrels/trillion cu. ft.

### Sukkur Rift Zone

The Sukkur Rift comprises a graben (Pano Aqil Graben) bordered by two horsts (Kandhkot - Mari Horst in the north and Jacobabad - Khairpur in south) formed as a result of rifting of the platform during Early Cretaceous (Fig. 1).

The Sukkur Rift Zone belongs to the main gas region of Pakistan. This area is dominated by high geothermal gradients of 4°C/100m. The heating event was caused by the Early Cretaceous rifting (Arif Kemal 1992).

The Kandhkot - Mari Horst consists of Mesozoic, Tertiary and Quaternary sediments. Five gasfields Kandhkot, Mari, Qadirpur, Kandhra and Badar have been discovered, out of which Mari and Kandhkot gas fields are on production. Gas in Kandhkot, Qadirpur, Kandhra and Badar is in the Sui Main Limestone (SML) and Sui Upper Limestone (SUL) while in Mari gasfield the reservoir is Habib Rahi Limestone. Sui Main and Sui Upper Limestone are of Early Eocene age while Habib Rahi Limestone is of middle Eocene. All the reservoirs are shallow platform carbonates with predominantly primary effective porosity. The gas was generated from Paleocene and Eocene source rocks.

Mari Gasfield, the second biggest gasfield of Pakistan is situated 60 miles north-east of Khairpur. It was discovered by Pak-Stanvoc Petroleum Project in 1957. The original reserves were estimated as 4.043 trillion cu.ft. Gas is obtained from Habib Rahi Limestone. The limestone is predominantly fine grained, fossiliferous, soft to medium hard and is 285 feet thick. The depth of pay zone is nearly 2050 feet below sea level and the average thickness is around 170 feet. The average porosity and water saturation was calculated as 19.8% and 34% respectively. (Hayat M. A. 1988). The Mari structure is relatively flat, broad anticline with gentle dips (Fig. 5 and 6).

The gas composition varies from well to well. The average composition of gas is Methane 72.73 %, Ethane 0.20 %, Carbon dioxide 7.7 % and Nitrogen 19.37 %. The main consumers of the Mari gas are EXXON Chemicals, Pak-Saudi Fertilizer, Fauji Fertilizer and WAPDA (for Power generation at GUDDU). The average daily production (July 1993 - March 1994) was 383 million cubic feet. (Table 3).

Kandhkot gasfield is 27 miles south of Sui gasfield. It was discovered in 1957 by Pakistan Petroleum Limited. The reservoir rocks are Sui Main Limestone and Sui Upper Limestone at about 4300 feet depth (Sohail 1986). Estimated recoverable reserves are 0.796 trillion cubic feet with average daily production of 93 million cubic feet. Analysis of Kandhkot gas shows Methane 76 -79% and Nitrogen 17-20 %. The Kandhkot gasfield has three subsurface domes, all having different gas/water contacts. Electric logs indicated that two stratigraphic markers interpreted as impervious layers subdivide the reservoir in three gas compartments. Each dome has a different main gas compartment, with relatively minor gas trapped in the

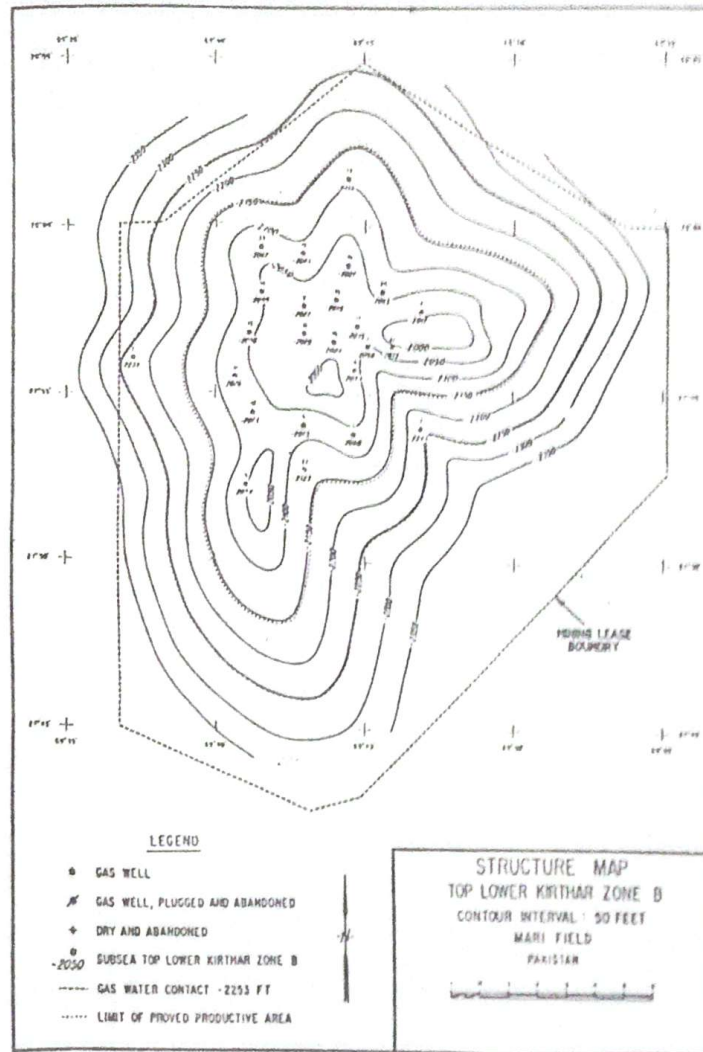


Fig. 5. Structure map of Mari Gas Field (after Hayat 1988).

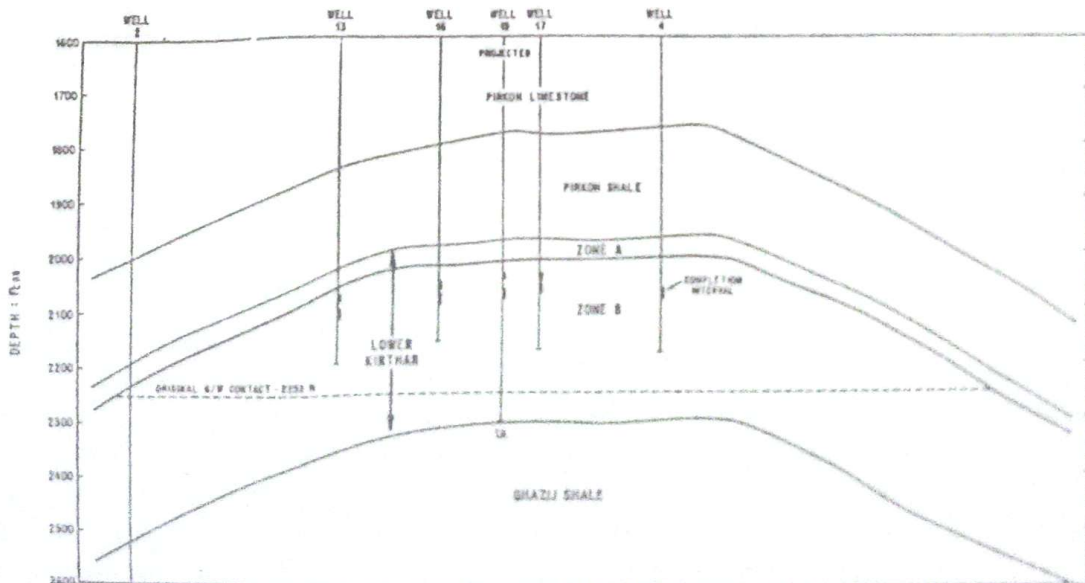


Fig. 6. East-West Cross Section of Mari Gas Field (after Hayat 1988).

other two (Siddiqui 1994). The production of gas at Kandhkot started in 1986. The gas is supplied to Guddu Thermal Station.

Qadirpur is a giant field of 3.978 trillion cubic feet reserves and is the third largest gas reserve discovered so far after Sui and Mari. The field is being developed in two phases. In the first phase about 200 million cubic feet daily of gas is expected to commence in September 1995 and an additional volume of about 150 million cubic feet will come on streamline in December 1996 in Second Phase (OGDC).

The Pano-Aqil Graben is a continuation of Cambay graben of India which contains several oil and gas fields. However no oil or gas has been discovered in Pano-Aqil graben so far. (Raza 1989).

In the Jacobabad-Khairpur Horst, in the earlier phase of exploration a small Khairpur gasfield was discovered in Sui Main Limestone. Recently a number of gasfields have been discovered in the south western part of this tectonic sub-zone. The newly discovered gasfields include Miano, Kandanwari and Gorwar. The reservoir rock in these gasfields is Lower Goru Sandstone of Lower Cretaceous.

Khairpur gasfield was discovered by PPL in 1956. The structure is a gentle dome with dips from  $5^{\circ}$  to  $10^{\circ}$  and a vertical closure of 300 feet. The reservoir rock SML is 2030 feet deep. The gas analysis shows the presence of 71% Carbon dioxide, 12% Methane and 17% Nitrogen. The reserves were estimated as 1 trillion cubic feet. No production has started from the field as yet.

The Kandanwari gasfield was discovered by LASMO Oil Pakistan Ltd. in 1989. It is the southern-most gasfield in the gas bearing region of Pakistan. The productive sandstone, Lower Goru of Lower Cretaceous has excellent reservoir characteristics (av. porosity 20% and av. permeability 643 md) which are usually good for such a deeply buried sandstone reservoir (3300 meters). The gasfield is expected to be on production in 1995 (Watts J. & N. V. Haq 1994). The Kandanwari gasfield is a stratigraphic trap.

Miano gasfield was discovered in June 1993, by Joint Venture Partners comprising OMV (Pakistan) as operator, Pakistan Petroleum limited, Hardy Oil and Gas (U.K.) Limited and O.G.D.C. Miano well no.1 tested gas at a rate of 33.5 million cubic feet per day from a stratigraphic trap in Lower Goru sand. In Miano well 2 gas was tested upto 51.6 mm cfd from a depth interval between 3303-3309 meters. The gas is of high quality. The gasfield is in appraisal phase (PROGRESS January 1995).

### **Mazarani Fold Zone**

The structures in this zone are large NNW-SSE oriented and elongated anticlines made up of Mesozoic and Neogene sediments. Only one gas field Mazarani was discovered here.

The Mazarani gasfield was discovered by PPL and Hunt in 1958. The anticline is large, assymmetrical with steep eastern flank. Gas and condensate was discovered in Sui Main Limestone at the depth of about 6225 feet. The estimated reserves are 0.09 trillion cubic feet. The gas is of good quality with associated condensate of about 280 gallons/milllion cu.ft. The field is not developed so far as it is located far from the gas transimssion line and the projected daily production is small due to small reserves (Sohail et al. 1986).

### **Karachi Depression**

There are a large number of assymetrical anticlines with steep eastern and gentle western slopes in this area. Gas was discovered in three strucrures Sarisingh, Hundi and Kothar in Ranikot Limestone (Paleocene) by O.G.D.C.

Gasfields of Sari and Hundi had reserves of 0.065 Tcf. Since these gasfields were located very close to the Sui Southern Gas Transmission line, these were hooked into the system in 1975. Presently gas producton from these fields is on decline (Table 3).

Kothar having the reserves of 0.017 Tcf. is dormant.

### **Sindh Monocline**

Sindh Monocline is the main oil and gas producing area where a large number of oil and gasfields have been discovered in **Badin Rift Zone** (Table 1). All the oil in Sindh is produced from this area (Table 2). **Badin Rift Zone** was formed as a result of rifting episodes during late Cretaceous (Fig. 1). The dominant feature of this area is tilted fault blocks which is clearly shown by cross section of the area (Fig. 7). The traps in this area are fault structures. The structural orientation of the traps is northwest to southeast. Closure to the north and east-west is usually formed by regional dip. Closure to the south is formed by faulting or a change in fault orientation (Mehmood-ul-Hassan 1994). Two sets of faults indicating two episodes of rifting during early Cretaceous Kutch rifting and late Cretaceous Cambay rifts are well recorded in Khaskheli structure (Fig: 8). In all the oil and gas fields in Badin area, organic rich Sembar shales deposited during Cretaceous are the source rocks. Lower Goru sandstone having porosity up to 30%

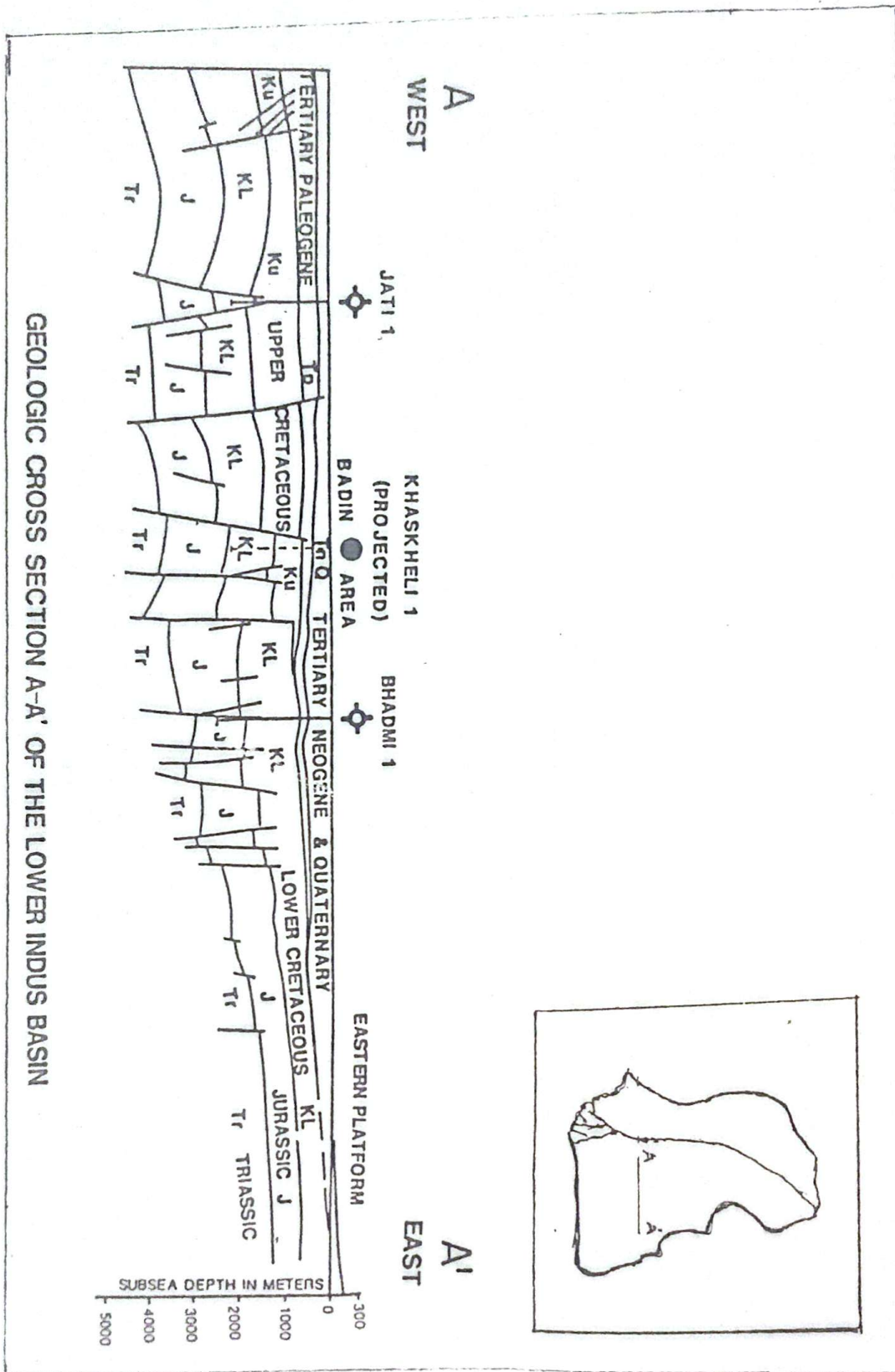


Fig. 7. Geologic Cross Section of the Lower Indus Basin (after Malik et al., 1988).

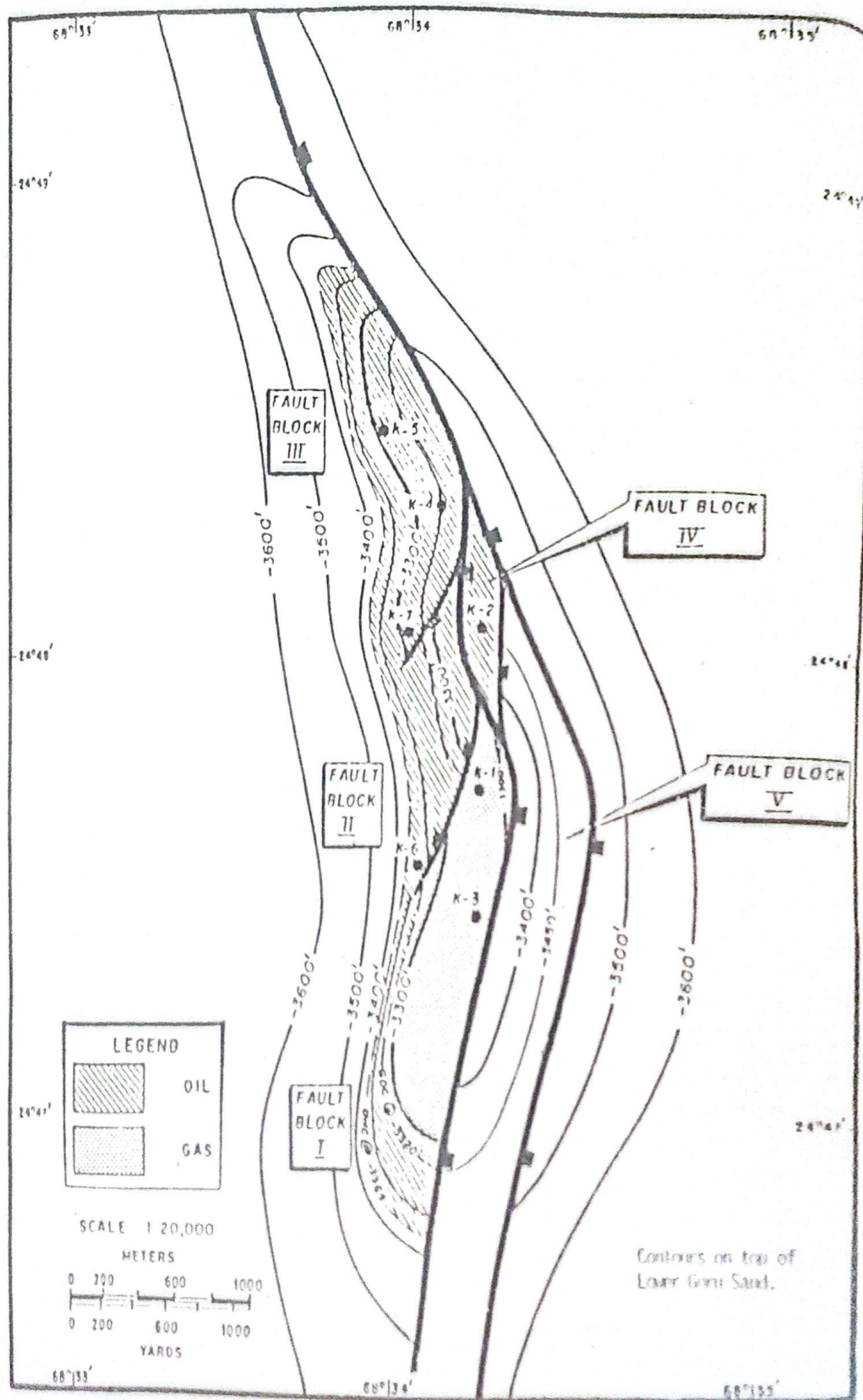


Fig. 8. Structural Map of Khaskeli Oil Field (after Saeed Ahmed and Ashton 1982).

is the reservoir rock, while the late Cretaceous Upper Goru shales provided excellent seal.

More than 40 oilfields and 16 gasfields have been discovered in Sindh Monocline, out of which 30 oil fields and 9 gasfields are on production (Table 2 and 3). It is interesting to note that a majority of gasfields in Sindh Monocline contain a substantial quantity of condensates (Table 2). Condensates are hydrocarbons transitional between gas and crude oil (gaseous in the subsurface but condensing to liquid hydrocarbons at surface temperatures and pressures). Chemically, condensates consist largely of paraffins, such as pentane, hexane and octane (Selley 1983).

The oil is transported to Karachi where it is mixed with imported crude (because of its large wax content) and refined. The gas is supplied to the Sui Southern Gas Transmission system.

### **An Analogy with the Moesian Platform Romania**

Study and comparison of petroleum basins and individual oil and gasfields form important guidelines for exploration and development of hydrocarbons.

Moesian Platform is a perfect analogue of the Indian Platform. The tectonic and geothermal history of the two Platforms show a remarkable resemblance (Memon 1994). Indus Basin and Ploiesti basin were classified as Extracontinental Downwarps by Klemme (1980). The Indian Platform and Moesian Platform are important forelands of these basins respectively.

In both the Platforms block faulting is dominant. The individual oil fields in the Moesian Platform and the oilfields in Sindh Monocline are fault structures. Main oil producing formations in the Moesian Platform are Mesozoic in which Jurassic sandstones and Cretaceous limestones are more important. In the Sindh Monocline oil and gas fields produce from reservoir sands of Cretaceous. It is hoped that further exploration will reveal oil deposits in the lower formations.

Geothermal gradients in the Moesian Platform have an average value of 3°C/100m. The hottest zone lies in the northern margin of the Platform where gradients exceed 4.5°C/100m. Average geothermal gradients in the Indian Platform are 2.45°C/100m. The central gas producing region of the Platform lies in the high gradient area having geothermal gradients of 4°C/100m.

Romania with an advanced oil industry is an important oil producing country for over a century. Although individual oilfields in the Moesian Platform are small in size like those in Sindh Monocline, they have fully exploited the area by extensive drilling.

Table 2

## Production of Oil (July 1993 - March 94) in Sindh

Company	Field	Total (bbls)	Ava. Daily (bopd.)
OGDC	Bobi (con)	105,050	383
	Buzdar (con)	5,905	22
	Kunnar	423,705	1,546
	Lashari-C	443,894	1,620
	Pasakhi	1,041,577	3,801
	Sono	700,211	2,556
	Tando Alam	341,310	1,246
	Thora	752,869	2,745
	Sub-Total	3,814,521	13,922
	UTP	Bachal	2,474
Bari		589,667	2,152
Bhatti (con)		11,266	41
Bukhari (con)		245,552	896
Dhabi		86,826	317
Ghangro		141,369	516
Golarchi (con)		5,235	19
Halipota		86,142	314
Khaskheli		213,337	779
Khorewah (con)		37,368	136
Laghari		334,520	1,221
Liari		449,604	1,641
Makhdoompur (con)		80,441	294
Matli (con)		9,940	36
Mazari		1,462,934	5,339
Mazari-s		817,432	2,983
Nari		9,414	34
North Akri		438,728	1,601
S-Buzdar-1		5,399	20
S-Mazari Deep		35,339	129
Turk (con)		132,057	482
Zaur		3,010	11
(Sub-Total)	5,198,054	18,971	
Grand total	9,012,575	32,893	

Source: Economic Survey 1993-94 Govt. of Pakistan, Finance Division Economic Advisors Wing, Islamabad.

Con = Condensate.

**Table 3**  
**Production of Gas (July 1993 - March 94) in Sindh**

Company	Field	Total mmcf*	Ava. Daily (mmcf/d)
MGCL	Mari	104,923	383
OGDC	Sari/Hundi	1,536	6
PPL	Kandhkot	25,447	93
UTP	Bachal (Ass.)	9	Negligible
	Bhatti (Ass.)	23	-do-
	Bukhari	14,983	55
	Dhabi (Ass.)	123	Negligible
	Golarchi	2,962	11
	Halipota (Ass.)	112	Negligible
	Khorewah	2,158	8
	Liari (Ass.)	128	Negligible
	Makdoompur	7,041	26
	Matli	4,269	16
	Mazari (Ass.)	648	2
	Mazari-s (Ass.)	147	1
	Nari (Ass.)	1,193	4
	Turk	9,927	36
Total		175,629	641

\*Million Cu.ft. *Source:* Economic Survey 1993-94. Govt: of Paksitan, Finance Division Economic Affairs Wing, Islamabad.

Ass. = Associated gas

### Conclusion and Suggestions

In view of the geology of Petroleum of Pakistan in general and Sindh (Lower Indus Basin) in particular, Sindh Monocline (Badin Region) is important producer of oil and gas. The average daily production of Petroleum, in the country, during July 1993-March 1994 was 57,880 barrels, out of which 32,892 BOPD were produced from Sindh (Economic Survey 1994). Sukkur Rift Zone is important gas producing region. With the development of newly discovered gasfields this region will be a major gas producer in future.

Although many oil and gasfields have been discovered in Sindh, the daily production of oil cannot be increased due to non availability of

sufficient refining capacity. The three refineries in the country, National Refinery and Pakistan Refinery at Karachi and Attock Oil Refinery at Rawalpindi, have a daily refining capacity of 140,000 barrels. Attock Refinery, which is the smallest and the oldest, refines all the crude oil (up to 30,000 barrels) produced in Potwar Region. The other two refineries at Karachi refine the imported and locally produced crude oil. The refineries at Karachi cannot take more than 26,000 barrels of local Badin oil a day due to its waxy composition. The surplus Badin Crude Oil is exported (Idris 1992). Our daily requirement of oil is about 2,650,000 barrels. Only about 58,000 barrels of oil is produced locally. The rest of the country's oil requirement is met by importing crude oil and refined Petroleum products.

A refinery in Badin will solve many problems. It will reduce the expenses which at present are made due to the transportation of crude oil to Karachi Refineries. Time has come when serious attention be given in this direction.

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