Oil Opportunities in Jordan

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ABSTRACT

Azraq basin consists of several geological structures, the Azraq area which is under study is approximately "1500" square kilometers, and about "33" wells have been drilled in different structures in this area.

The study which prepared for NRA with a cost of about USD (2) millions, evaluated the hydrocarbon potential in the area. The study indicated that an estimated of about (430) million barrels of oil have been generated from the WS-2 member in the Azraq area.

The Hamzeh field contains stock tank oil in place ranging between (15.2-22.5) million STBO. While (NPC) produced not more than (1) million barrel of oil since 1988.

Two heavy oil wells have been drilled in the area, the data obtained about these two wells indicates the presence of a vast amount of heavy oil and asphalt which could obtain crude oil by converting it by technical methods.

Some wells drilled in other structures in this area, data obtained showed the presence of (good-strong) oil shows.

The Dead Sea area is about (3750)square kilometers, many oil seeps are available in Dead Sea area, most of the oil fields in the world had been explored or discovered through the seeps around it, again I would say that the Dead Sea is wealthy by seeps.

Significant oil seep in Wadi Asal, south of Lisan peninsula on the eastern side of the Dead Sea, another historic seep at Ain-Hummar which is (5) Km south of Wadi Mujib to the north of the Lisan Peninsula, it was described In 1939.

A core-hole drilling program in the area produced samples with an average organic carbon content (TOC) over 10%.

One of the wells which had been drilled in Wadi Sirhan area gave us the best quality of oil (sweet oil) with a gravity of (43°) API.

Other (5) blocks in Jordan that we can work on it for oil exploration are: East Safawi Block, West Safawi Block, North Jordan Block, Jafr-Central Jordan Block, and Wadi Sirhan Block.

INTRODUCTION

Several oil companies started work in the exploration for Petroleum in Jordan.

Between 1922 and 1947, sporadic studies were made of the petroleum possibilities of Trans- Jordan, as it was then known.

Between 1947 and 1949, the first comprehensive geological studies for petroleum exploration took place, and were carried out by Petroleum Development (Trans_ Jordan) Ltd (a subsidiary of the Iraq Petroleum company). However the company surrendered the concession in 1949 without any drilling.

Between 1949 and 1978 , different oil companies worked in Jordan , and drilled several wells , part of it in West Bank , Which showed weak oil and gas shows , the others are in (Wadi Azraq / Sirhan) , one well in Wadi Rajil which is (Wadi Rajil _ 1) encountered good to strong oil shows .

Most other exploration wells and stratigraphic tests since 1972 have been drilled by Natural Resources Authority of Jordan (NRA) which resulted in the discovery of the small Cretaceous reservoir in the Hamzeh oilfield, and the Risha (Ordovician reservoir) gas field, both of which are in production.

In 1985, oil Companies renewed their interest in Jordan.
Mean while (NRA) continued to drill well clusters around its discovery area in Risha and around the Wadi Sirhan of light oil 43° API gravity which tested from Ordivician clastics.

It can be concluded that Jordan is still poorly explored.

Natural Resources Authority of Jordan (NRA) divided the country into (8) exploration areas **(Fig. 1)**

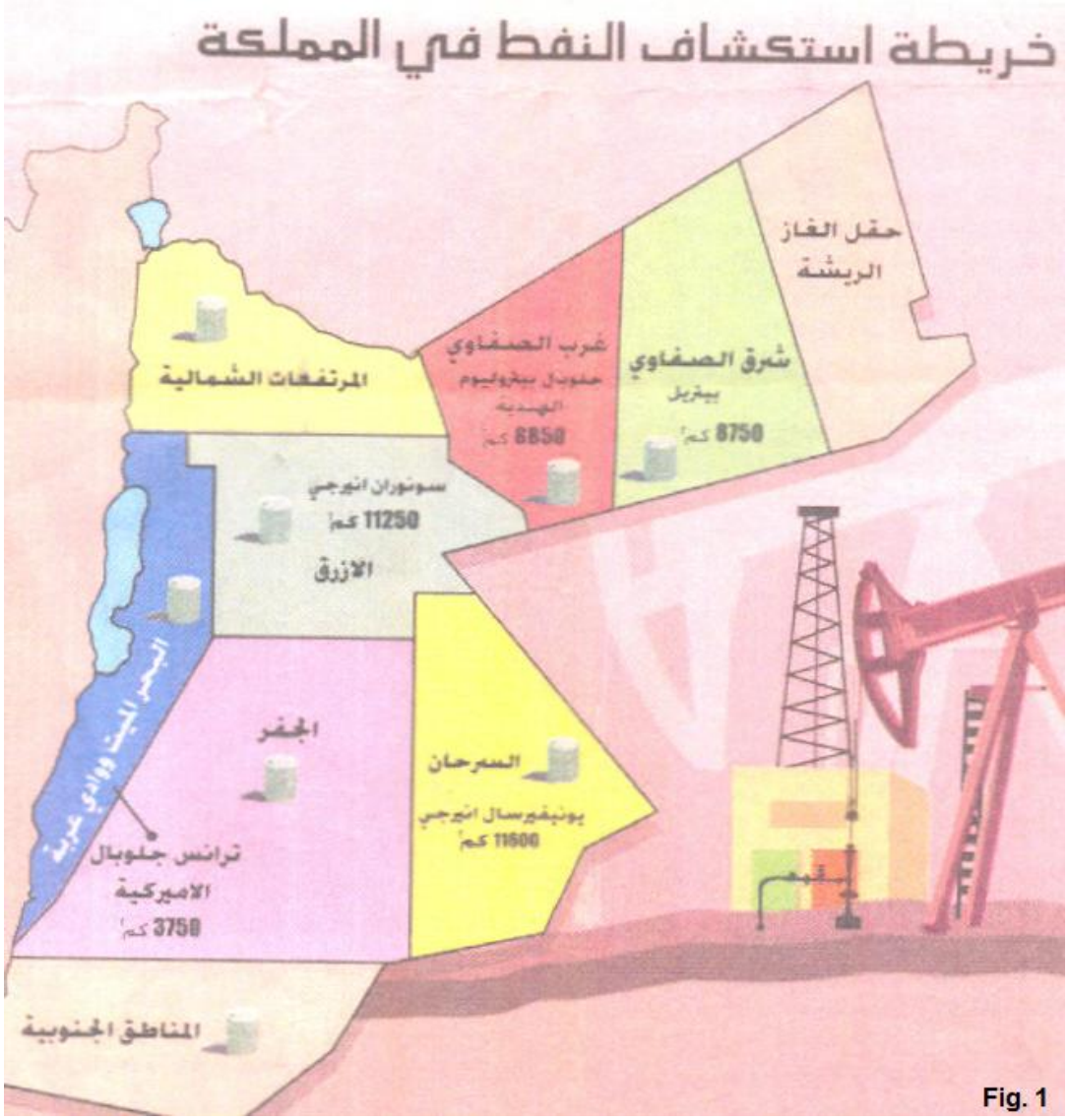


Fig. 1

1. Azraq Area.
2. Dead Sea Area.
3. Sirhan Area.
4. East Safawi Area.
5. West Safawi Area.
6. Jafr area.
7. Northern Jordan Area.
8. Risha Area.

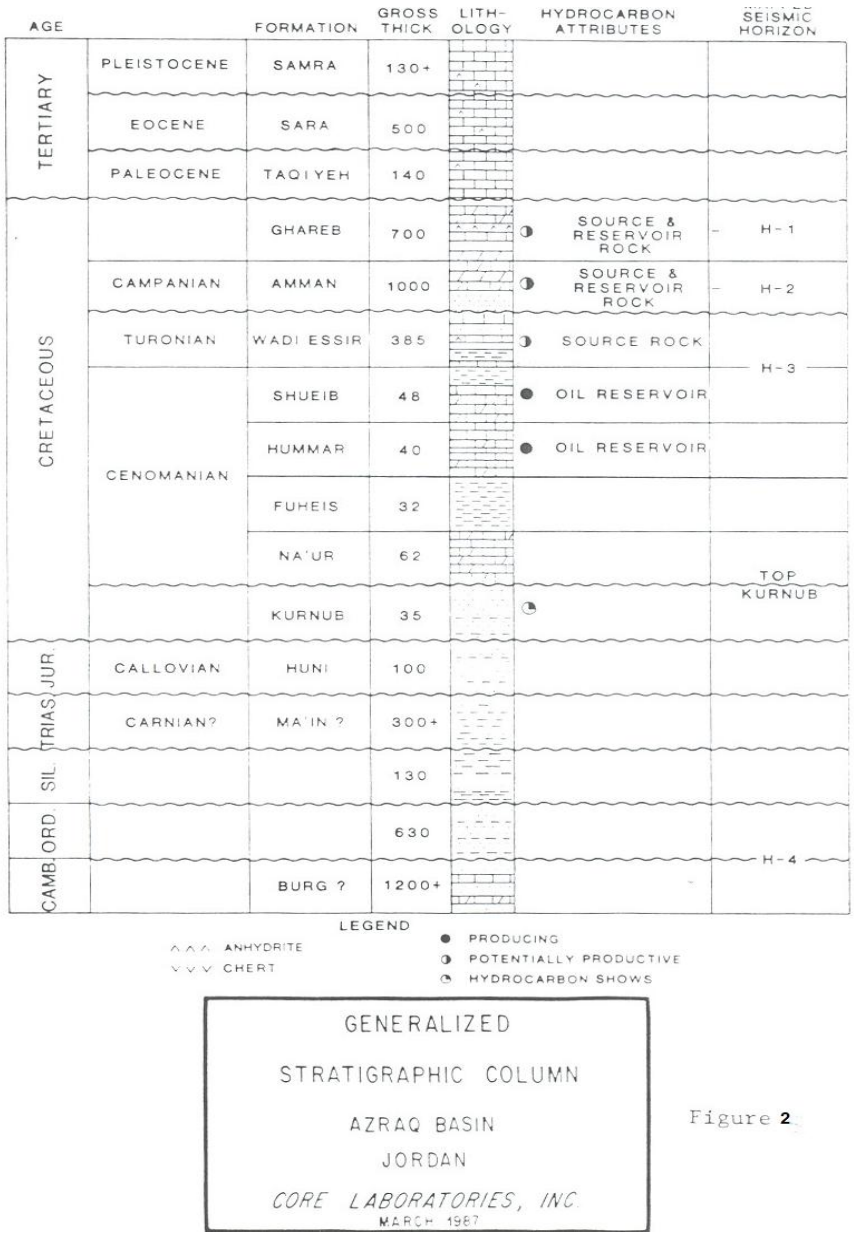
I have attempted to present an integrated picture of the oil opportunities in Jordan but my presentation will cover Azraq and Dead Sea areas only.

<u>Azraq Area</u>:

Azraq area is about of (11,250) km², there are several geological structures in the area caused by faulting.

The sedimentary column in Azraq Basin is composed of Carbonates, sandstones, and shale sediments with a thickness of about (5,500) m.

(Fig. 2)



GENERALIZED

STRATIGRAPHIC COLUMN

AZRAQ BASIN

JORDAN

CORE LABORATORIES, INC.

MARCH 1987

Figure 2

The boundaries of the Azraq Basin are formed by a strike-slip Fuluk Fault to the North (N) and Northeast (NE), and a strike -slip Suwaqa fault to the South. **(Fig. 3)**

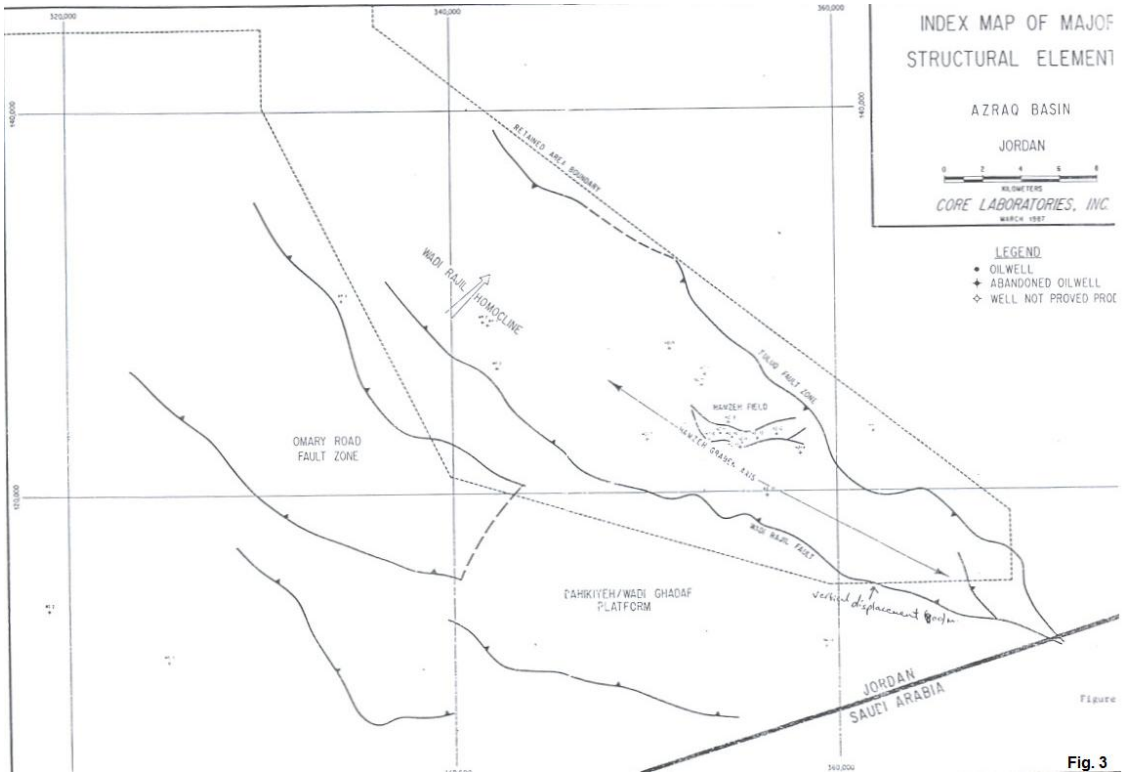


Fig. 3

Azraq Basin is approximately similar to the oil fields of south western Iran **(Fig. 4)**

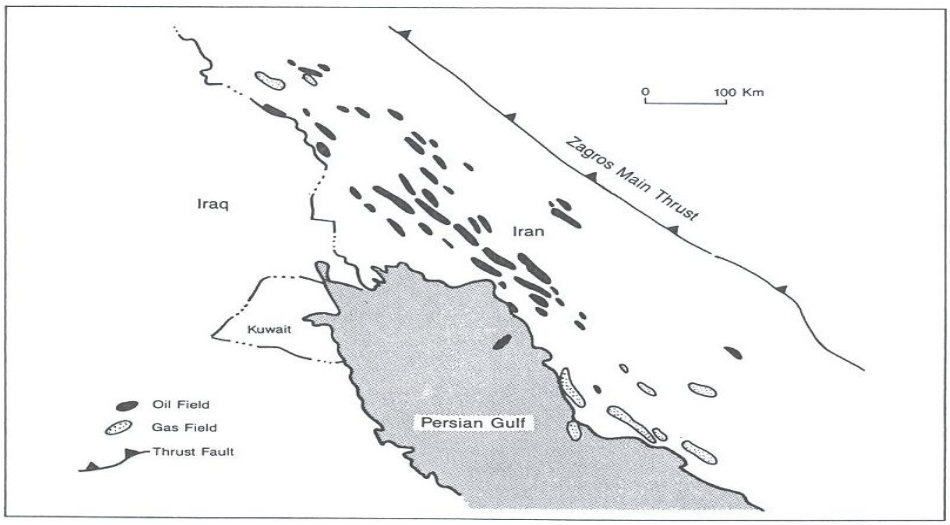


Fig. 4 . Continent to continent convergent margin with oil fields of southwestern Iran.

And the southern Trinidad – Venezuela transform margin. **(Fig. 5)**

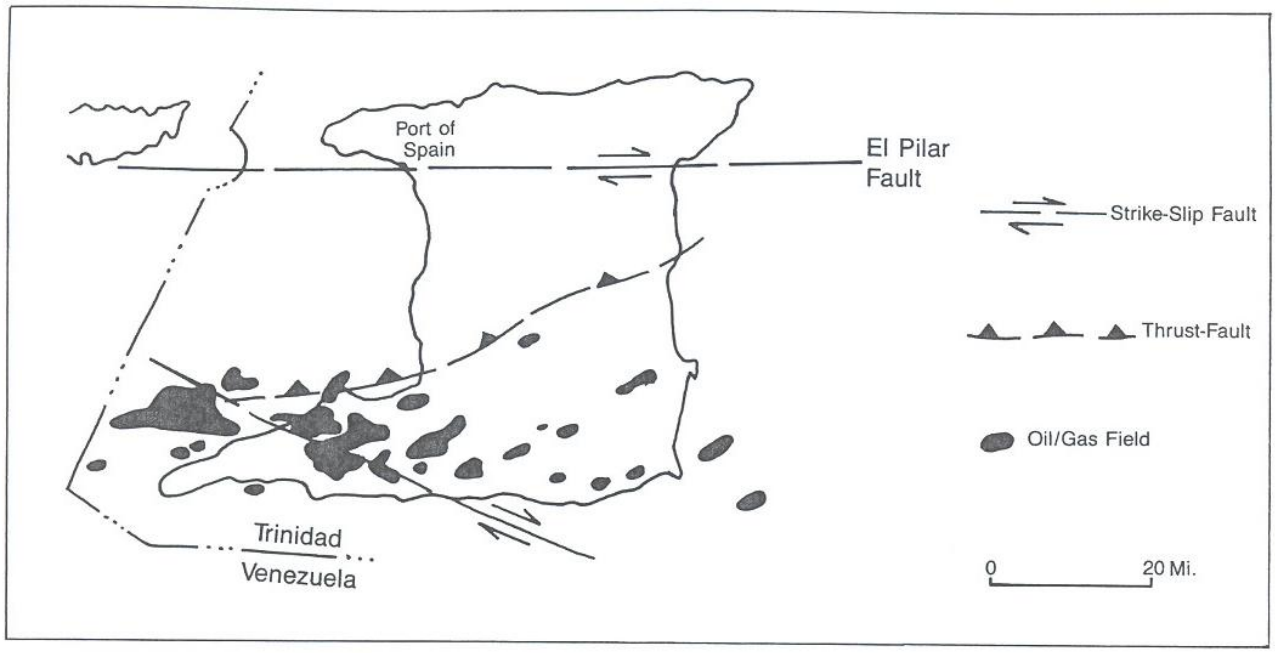
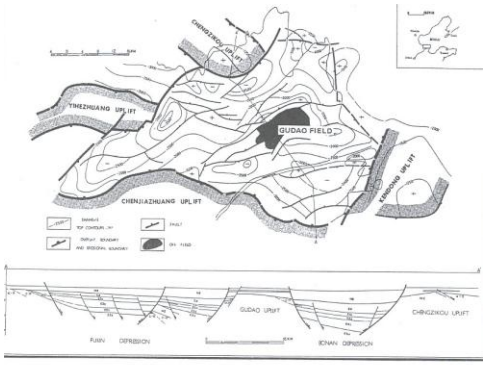


Fig. 5 .. Index map of southern Trinidad transform margin.

Also in China, Zhanhau Basin, Gudao Field, **(Fig. 6)**



Gudao Field, Zhanhau Basin, China. From Chen and Wang, 1980. Permission to publish by AAPG. **Fig. 6**

Structurally the basin is similar to Azraq Basin. **(Fig. 7)**

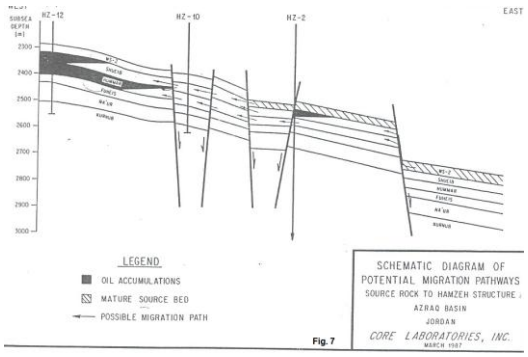
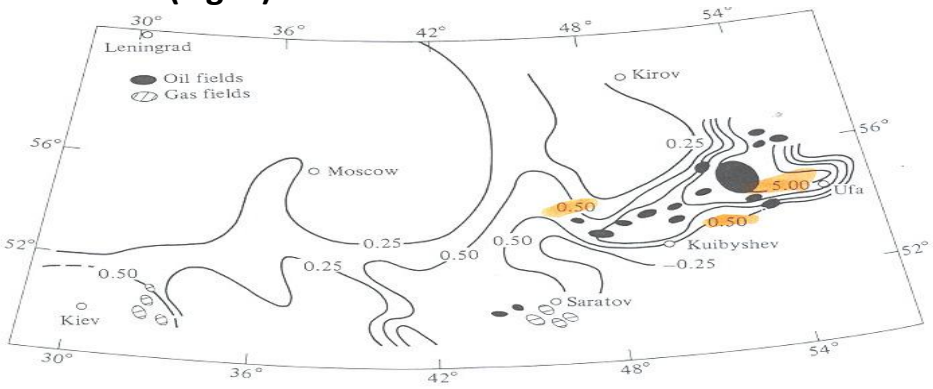


Fig. 7

The most important requirement for petroleum accumulations is the source-rock, in addition to that, the most important factor in the origin of petroleum is the thermal history of the source rocks.
In general, the total organic content of such sediment which is eventually become source beds of petroleum ranges between (0.5 % and 5.0 %) TOC.
The minimum TOC for a fine grained shale to generate sufficient oil for commercial accumulations ranges between (0.4 % and 1 %)

The Oil fields in the Russian platform are all concentrated in the area near Kuibyshev and Ufa, where the organic carbon content ranges between (0.5 % and 5.0 %) TOC, while the platform has structures and interbedded sands with good porosity and permeability through out this area, but no oil fields there. **(Fig. 8)**



Organic carbon content of Upper Devonian sediments from the Russian Platform. The contours represent over 1,000 combined analyses of fine-grained rocks. [Ronov 1958] **Fig. 8**

There are several proved source-rock units in Jordan, which have varying qualities and maturation levels. In (NE) they are highly mature; they are probably an effective additional source- rocks for the gas accumulations of the Risha area.
In Central and Southern Jordan, the source-rocks are thermally mature, and act as a possible source for oil in the Azraq-Sirhan Basin and the eastern part of Al Jafr depression.
In Wadi Essir formation, WS -2 member considered to be the main source-rock for the Azraq Basin Hamzeh Oilfield in Hummar and Shueib reservoirs.

Thickness of WS-2 member is (33) m., and consists of planktonic foraminiferal argillaceous sediments (mudstone / wackestone) and carbonates. The oil generated from this member is a Type kerogen 11

cycloparafines (nephthenes and aromatics), which are the fairly high original hydrocarbon content. **(Fig. 9)**

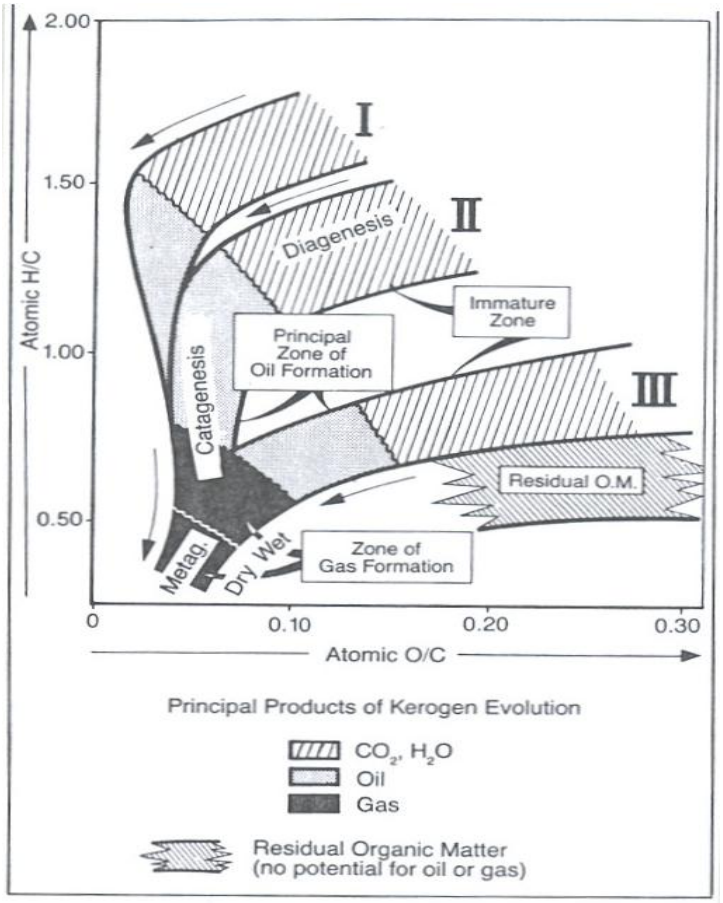


Fig. 9 . Evolution of kerogen in petroleum formation. From Tissot, 1984. Permission to publish by AAPG.

TOC in WS -2 member ranges between (0.1% and 4.0 %) which is a high organic content.

WS -2 source rocks are buried below (3,000) m.

Oil generation initiated when these sediments were buried to a depth of approximately (2,500) m. with the most effective generation occurring when the sediments were buried below (3,000) m., at this depth the temperature is (90° c) which is in the temperature range in the catagenesis stage, where the largest quantity of petroleum hydrocarbons are formed from organic matter heated in the earth between (60° c and 200° c).

Oil Production in Azraq Basin (Hamzeh Field):

A study area of approximately (1,500) km² in Azraq Basin has been prepared by Core Lab for Natural Resources Authority of Jordan (NRA) in 1987 to identify the potential hydrocarbons. Seventeen wells have been drilled in Hamzeh field. Medium gravity of 3o˚ API produced from (4) wells.

The Azraq Basin estimated oil generation (430) million barrels of oil from the source rock WS-2 member of Wadi Essir formation, of which 10% are reservoired in very tight Limestone reservoirs which are Shueib and Hummar. The source is located above the reservoirs. Oil in place in Hamzeh field ranges between 15.2 and 22.5 million STBO.

Migration in the Hamzeh field occurs through the down faulted segment to the upper thrown segment of the structure.

The cumulative production reached only the one million barrel of oil, while significant oil production was also recovered from the source rock interval which its thickness is (33)m. above the producing reservoirs, but not produced. Horizontal drilling and fracturing would eventually make this source interval a producer.

Oil Production of about (200 -500) bbl /day has been established from the Hamzeh Field, while in **"THE MIDDLE EAST : REGIONAL GEOLOGY and PETROLEOM RESERVOIRS"** by Z.R . Beydoun, pages (184 and 185) reported that the production in Hamzeh Field in 1985 was about (2,000 _ 2,500) bbl/day.
There are also several structures similar to the Hamzeh field and located close to it could also be drilled and connected to the current production facility.

Recently one well in Hamzeh field has been swabbed produced more than 350 bbl/day, while the current production is (27) bbl/day.

This field has no serious work over program since the 1980s. If a serious work over program is employed in this field, it could produce (2,000-3,000) bbl/day.

Heavy Oil in Azraq Area:

Two heavy oil wells have been drilled in the area which is HO-1 and HO-2. The data obtained from these two wells indicate the presence of a vast amount of heavy oil of about 18˚ API gravity in Ghareb formation which is widely distributed in Jordan, and in Amman formation but this formation contain less potential for producing heavy oil.

Due to the economic condition, secondary recovery operations are marginally attractive, the heavy oil could be converted to movable crude oil by using the following methods or techniques:

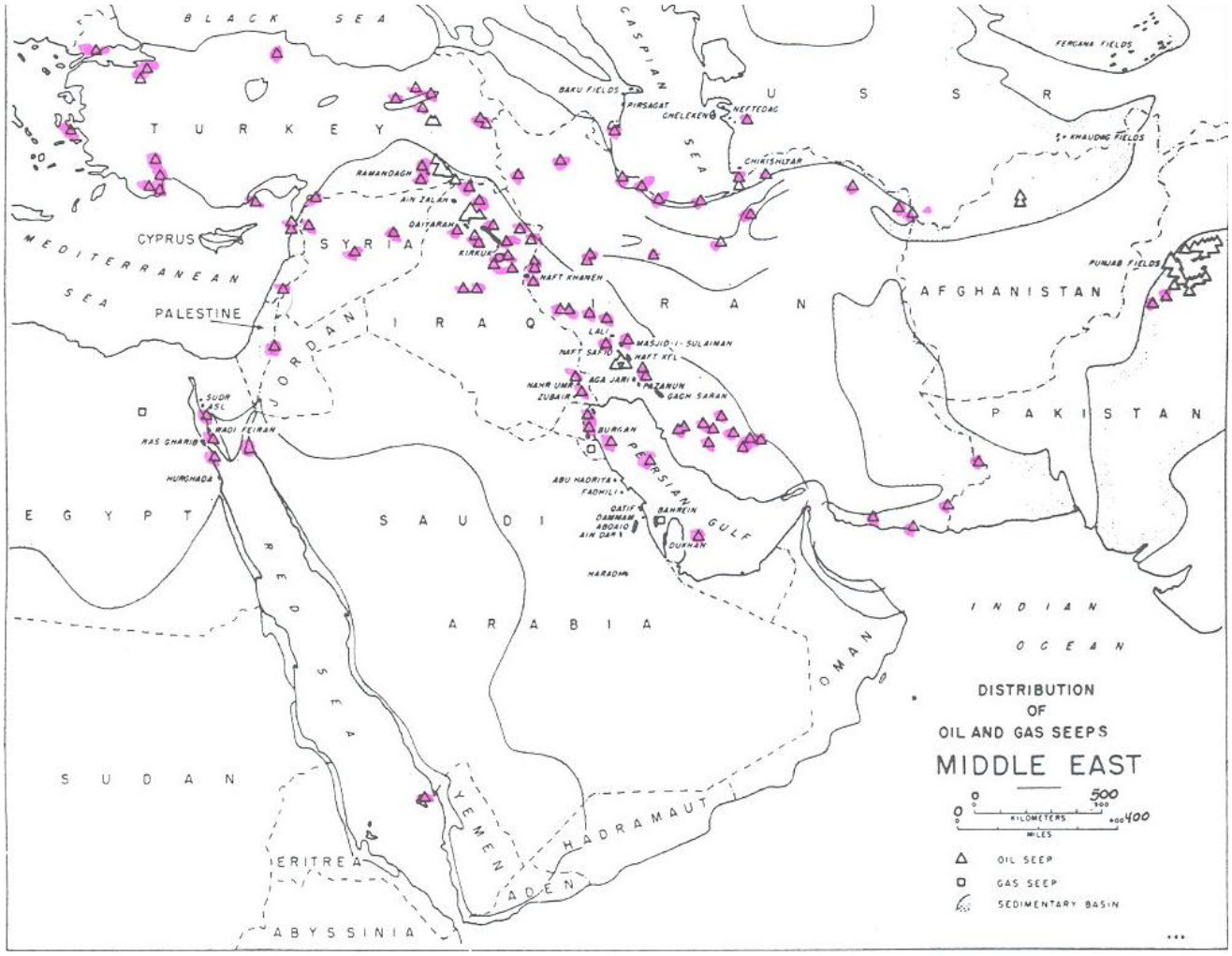
1. Steam injection.
2. Using the most modern techniques.

Dead Sea Area:

Dead Sea Area is about (3,750) km^2.

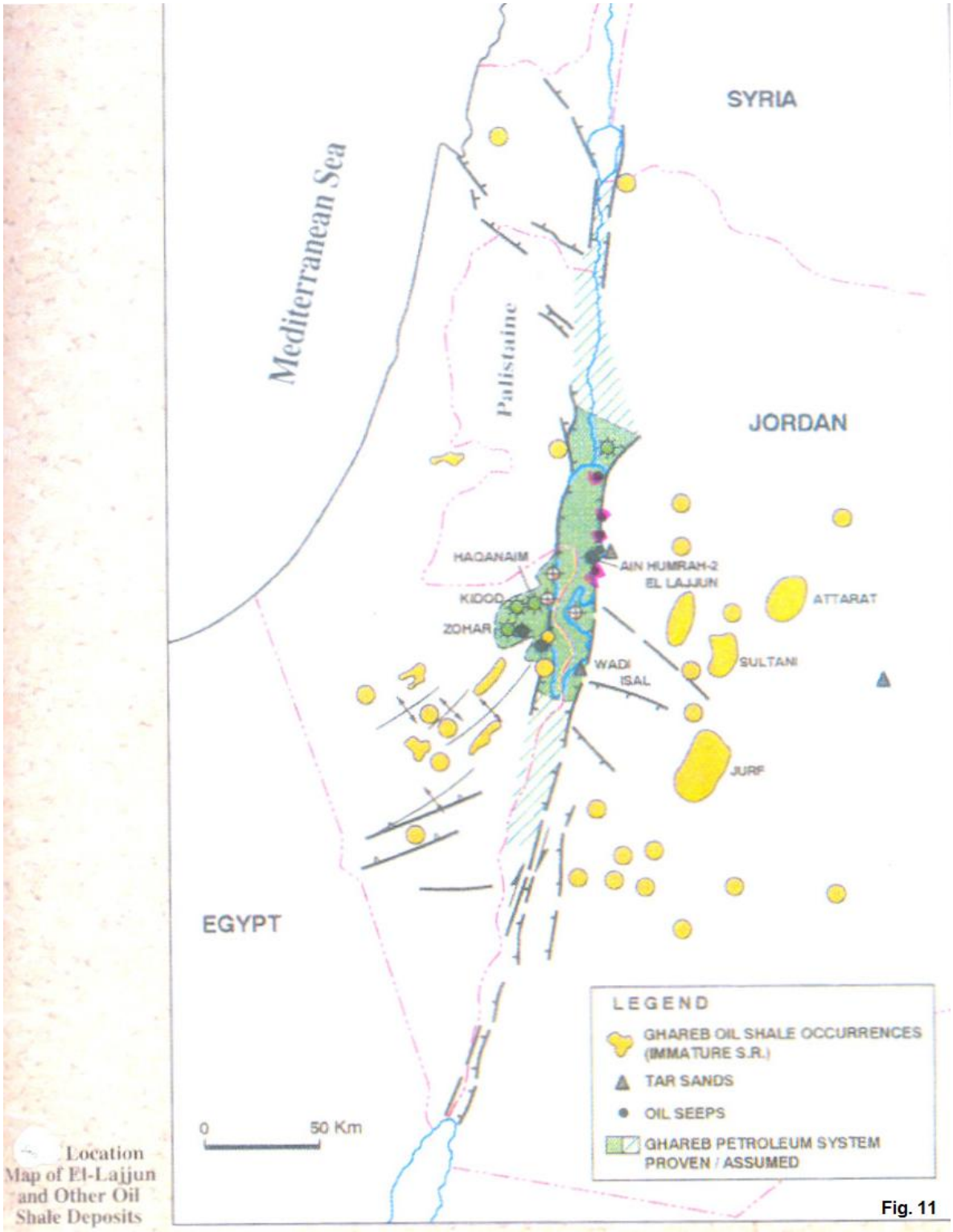
Visible oil and gas seeps are important in an exploration program, and are the most important indication for commercial oil accumulations.
Hydrocarbons in Jordan are indicated by numerous oil seeps, gas indications, tarsands, heavy oil and floating asphalt blocks in Dead Sea waters and on the shoreline.

There is a map shows the distribution of oil and gas in the Middle East which the Dead Sea Area is involved. **(Fig. 10)**



Distribution of oil and gas seeps in Middle East. From Link, 1952. Permission to publish by AAPG. **Fig. 10**

The most significant oil seep is that of Wadi Isal, just south of Lesan Peninsula on the eastern side of the Dead Sea. **(Fig. 11)**



Another historic seep is located at Ain Humrah (5)km south of Wadi Mujib to the north of Lisan Peninsula, this was originally described in 1939 and was re- exposed during construction operations in the area .

A shallow (250) m. bore hole drilled by (NRA) encountered a reported 40 bbl/day oil flow consisting of aromatic, non-degraded conventional 29° API crude oil in the Cambrian "Burj Limestone'' **(Fig. 12)** and other occurrences of oil seeps and tar sands in the Dead Sea Area.

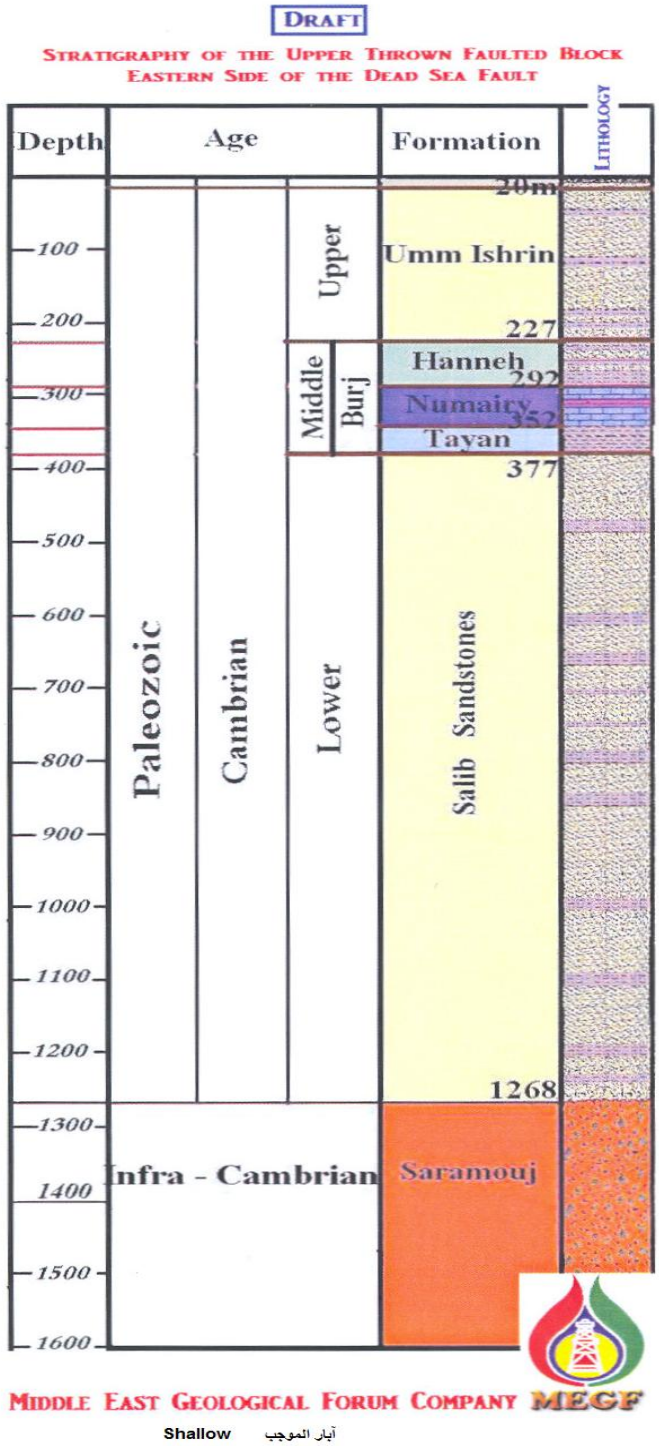
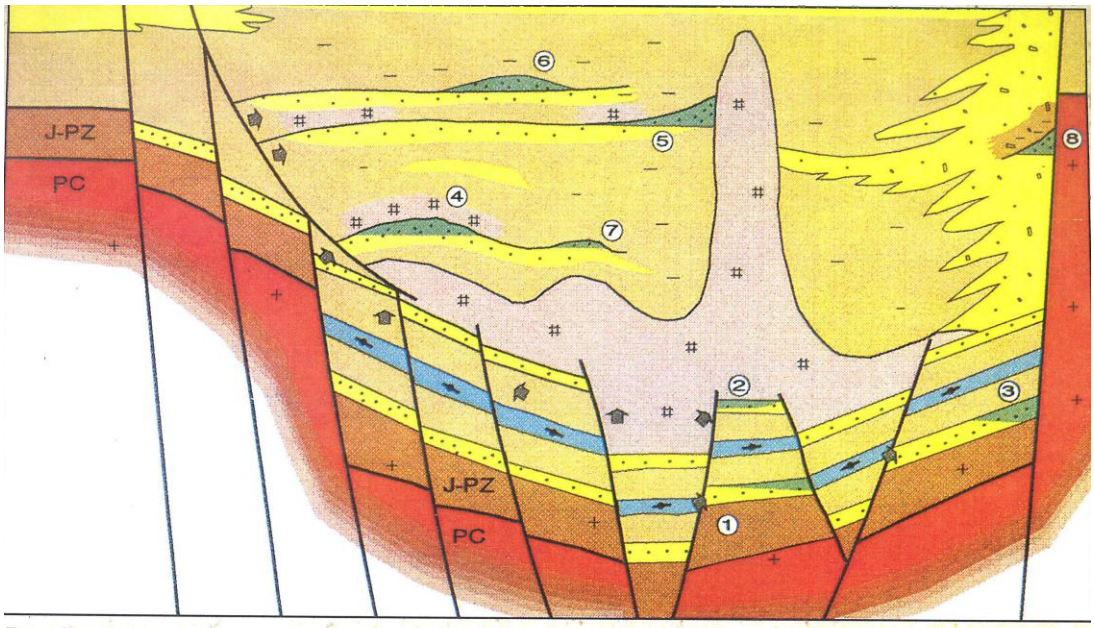


Fig. 12

Surface samples from central and northern Jordan on the east side of the Jordan Valley were analyzed and recorded regional organic-facies variations in the formation, with organic–matter contents ranging from lows of (0.1%- 40%) TOC. The formation is immature at the surface, but where it has been buried under a thick Tertiary load, such as in Dead Sea graben, it has become mature and has generated oil. **(Fig. 13)**



Pre - Salt Play

① Fault Block Wht. Lk Kurnub Sst

② Fault Block Wht. Miocene Hatseva Sst

③ Lk Kurnub Sst Juxtaposed to Bstm Along Main Border Fault

Post- Salt Play (Pleistocene SST)

④ Rollover Structure

⑤ Strat. Trap Against Salt

⑥ Mounded Structure

⑦ Drape Over Diapir

⑧ Strat. Trap Against Basement

Fig. 13 Schematic Play Summary Dead Sea Rift Basin

A core-hole drilling program in the area produced samples with an average organic carbon content (TOC) over 10 %.

In a reference book which is **"Geology of Petroleum''** by **LEVORSEN** , second Edition, copyright 1954, 1967, on page 19, he states {**At one time the Dead Sea, around which many saturated sands, seepages, and bitumen deposits occur was called ''Lake Asphaltites". Asphalt chunks are still found floating on it, but their source is unknown}.**

Now it is known that Muaqqar and Ghareb formation are the sources of asphalts and oils in the Dead Sea Area.

Several shallow and deep wells have been drilled in Dead Sea Area on poorly-constrained structures which had no definite closures, or were based purely on stratigraphic information, some early wells were drilled without the benefit of seismic surveys, and yet others were sited on salt features.

Salt and shale structures:

Salt and shale move in response to sediment -loading and deform the rocks associated with them.
Traps form with the deformation and occur along the margins and crests of salt and shale domes and pillow structures.
A seismic Section in Dead Sea Area **(Fig. 14)** shows salt massive, which could be traps formed with the deformation and along the margins and crests of the salt dome and the pillow structures **(Fig. 15)**

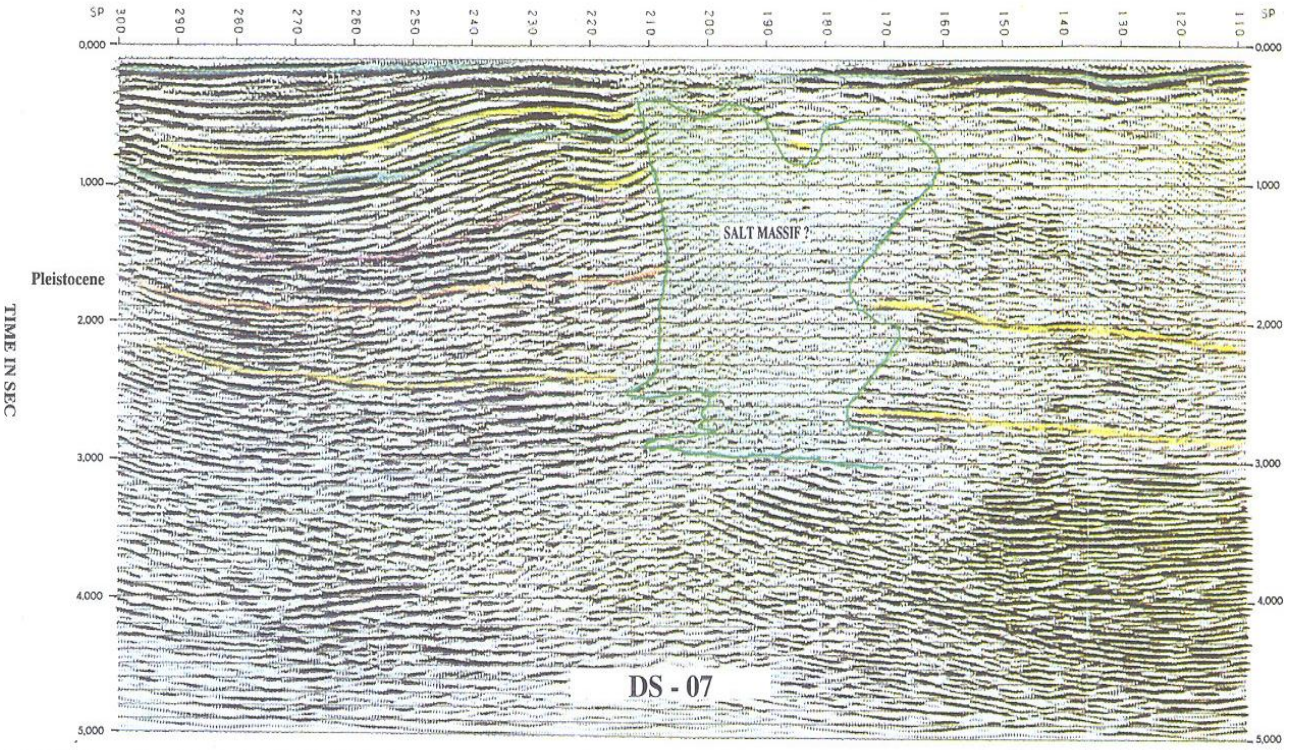
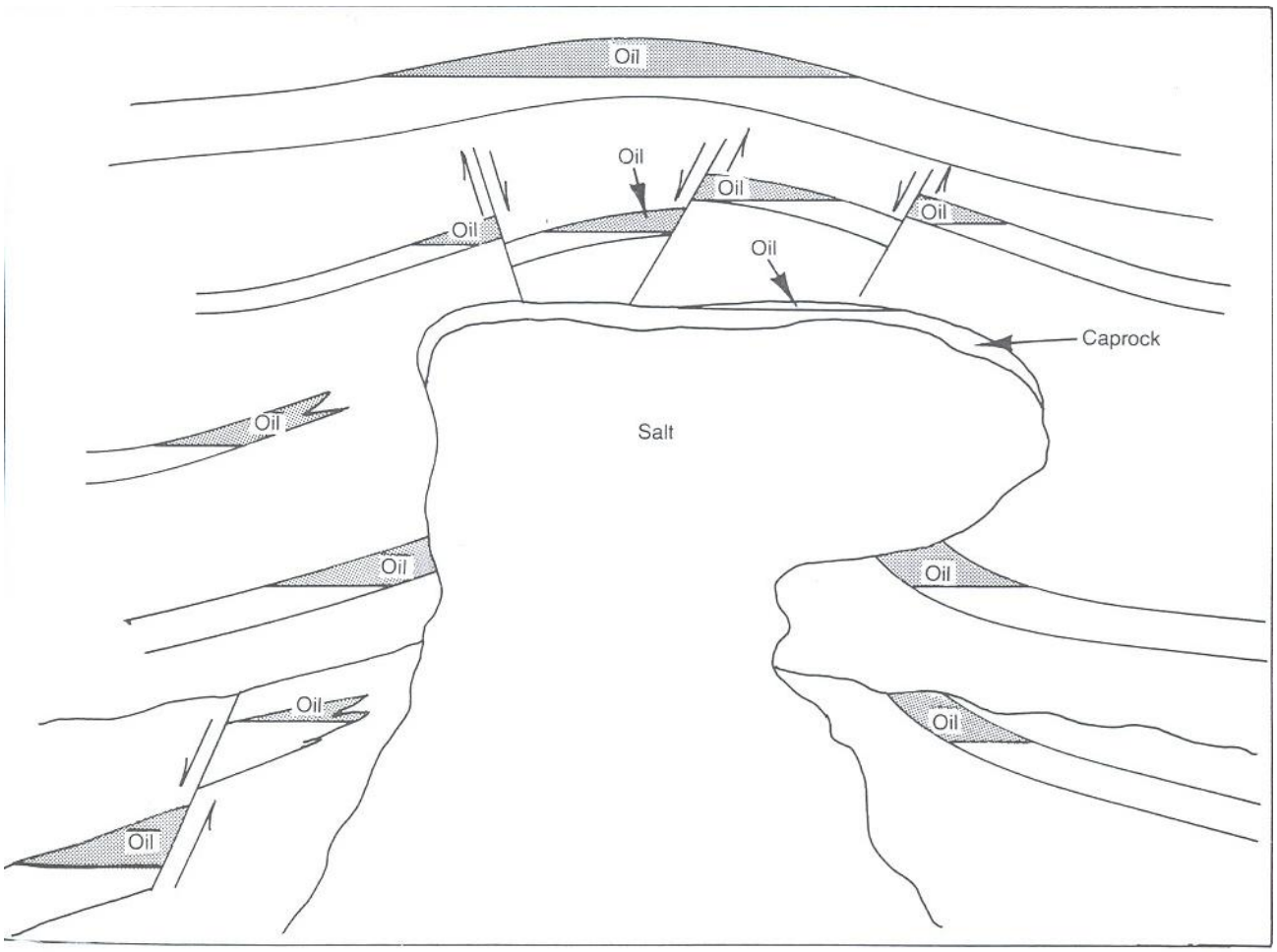


Fig. 14 Seismic Section in Dead Sea Area Showing Salt Massive and the Drape of Pleistocene and Other Rocks at the Salt Massive

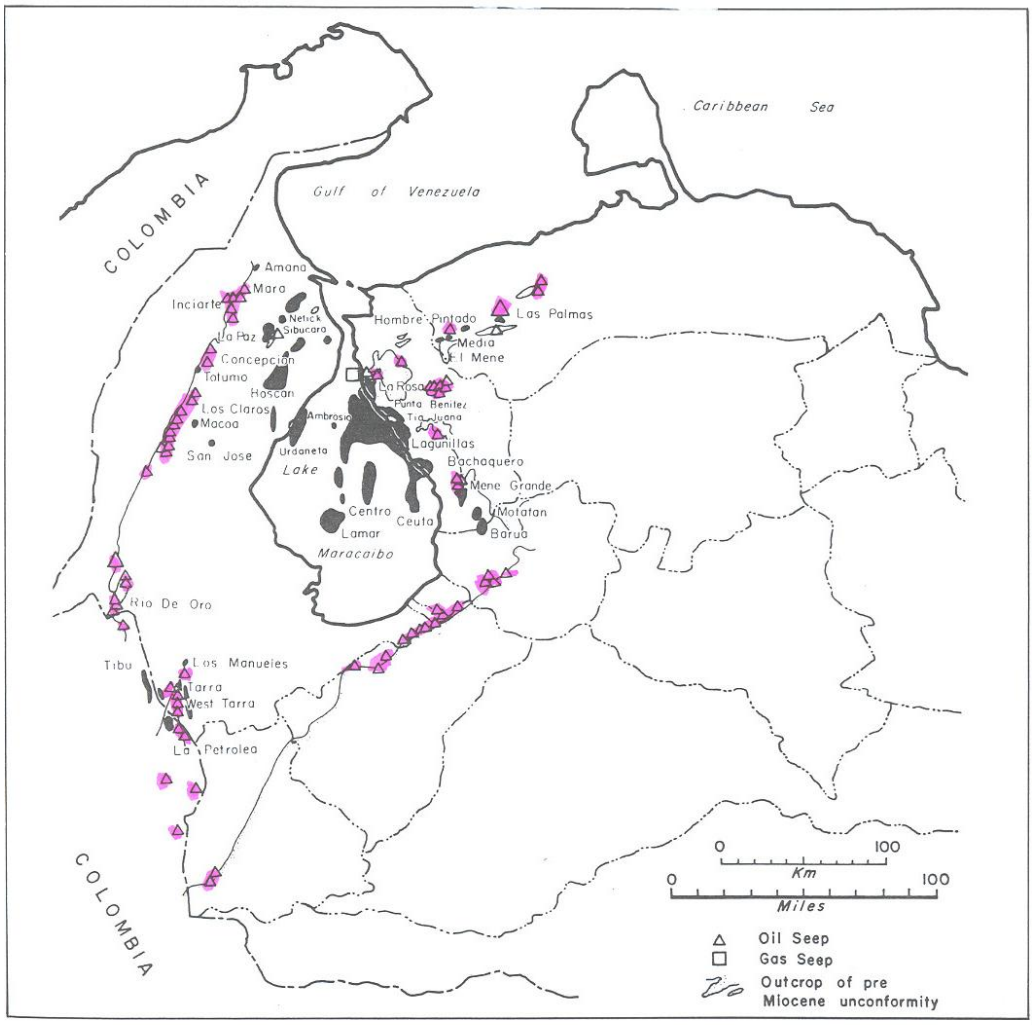


Salt structure traps

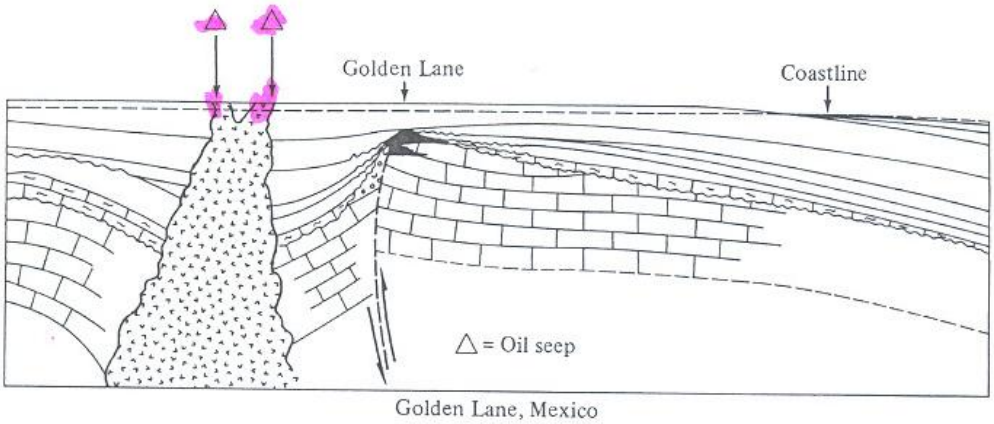
Fig. 15

Some examples on oil fields had been explored by oil seeps such as:

- Western Venezuela **(Fig. 16)**
- Golden Lane, Mexico **(Fig . 17)**
- Masjid – Suleiman Field, Iran **(Fig . 18)**
- USA, Oklahoma **(Fig . 19)**

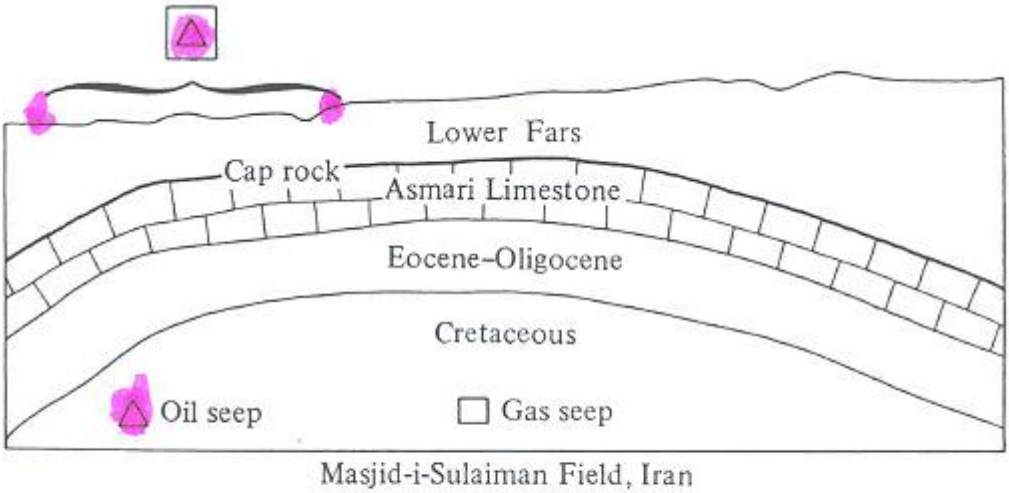


Oil seeps in Western Venezuela. From Dickey and Hunt, 1972. Permission to publish by AAPG. **Fig. 16**



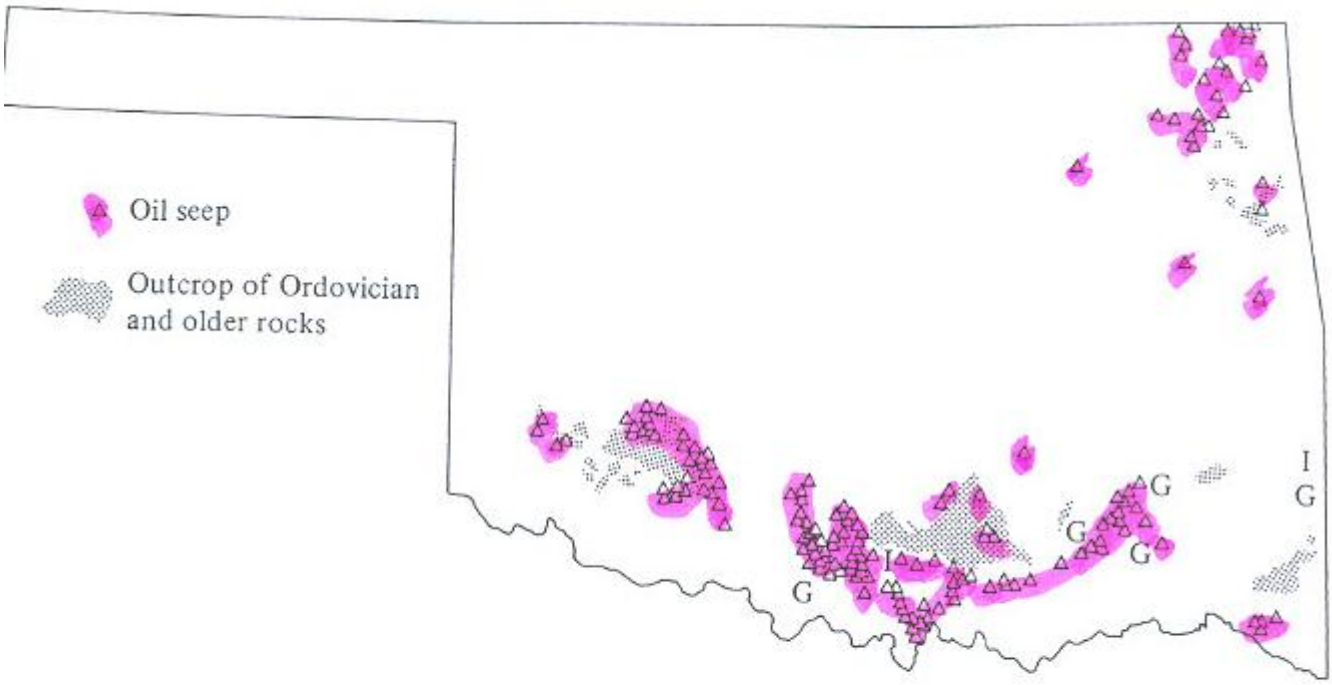
Golden Lane, Mexico

Type 5 seepage of oil possibly formed by heating of source rocks penetrated by igneous dike near Golden Lane production of Mexico. [Link 1952] **Fig. 17**



Type 3 seepage of oil from the Asmari Limestone at Masjid-i-Sulaiman field in Iran. [Link 1952]

Fig. 18



Oil seeps and asphalt-saturated sands of Oklahoma. G indicates the asphaltite grahamite; I indicates the pyrobitumen impsonite, both of which represent advance states of asphalt maturation. [Dickey and Hunt 1972]

Fig. 19

Conclusions:

1. Two major source-rock levels are widely distributed across Jordan. The first is represented by the shale's of the lower Silurian Mudawarra Formation, and WS-2 member which are present in an eastwards–thickening and deepening belt from the SW to the NE of Jordan, occurring widely in the eastern part of the country beneath younger sediments, and continuing into NW Saudi Arabia and western Iraq. These deposits are generally immature in the SW, but reach high maturity in the NE. as in Akkar in western Iraq, Risha Gas Field, and Hamzeh Oil Field.

   The Second major source–rock level is represented by the argillaceous carbonates of the Muwaqqar (Ghareb) formation, which crops-out over much of Jordan.

   These deposits are mostly immature, but where they are deeply buried (such as in the Dead Sea graben) or the deepest part of the Azraq graben, sufficient maturation has been achieved for the generation of oil.

2. An estimated 430 million barrels of oil have been generated from the WS-2 member in the Azraq Area.

3. Hamzeh field contains oil in place values ranging between (15.2- 2.5) million STBO.

4. Due to the economic conditions to date, secondary recovery operations are marginally attractive.

5. There is a vast amount of heavy oil which could be converted to movable oil.

6. Hamzeh field has no serious work over program since 1980s.

7. Jordan is still poorly explored.

Recommendations:

1. The most important priority is to make 3-D seismic survey on the Dead Sea Area.
2. If a serious work over program is employed in Hamzeh field, it could be produce (2,000- 3,000) bbl/day.

3. Data collection should continue especially additional core analysis for the unanalyzed cores.

4. Geochemical studies should be made in lower cenomanion and Triassic samples to determine if these intervals are capable of generating hydrocarbon, especially in areas outside the Hamzeh field.

5. Horizontal drilling technology and fracturing job would eventually make the source interval in Hamzeh field producer.

6. There are several structures similar to the Hamzeh field and located close to it could also be drilled and connected to the current production facility.

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