# PALEOGRAPHY A TOOL FOR OIL EXPLORATION IN PAKISTAN

By

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*Introduction.*

A study of the history of oil exploration in various parts of the world reveals definite stages. Initially, about a hundred year back, the oil search was limited to areas where oil seepages were known to occur. Later exploration shifted to anticlines after a genetic relationship was established between oil traps and structure. In the final stage where the structural traps failed to provide the oil or where sufficient subsurface data has been collected, search for stratigraphic traps were initiated.

In the present paper the author will analyse the progress made in this endevour to find oil in Pakistan and to suggest new avenue of exploration.

Discovery of oil in commercial quantity was first made in 1859 in the state of Pannsylvania when the famous, Col: Drake struck oil in a shallow well. Subsequent well near oil seepages, however, did not yield oil in quantity as the drillers expected.

The various stages mentioned above may be overlapping in some countries, although the world's major production today comes from structural traps. Lately, the shales have become a great potential source for oil and several oil companies have successfully extracted oil in commercial quantity from the vast asphaltic deposits near Fort McMurray, Alberta, in western Canada. Thus it seems that while the second and third stages were reached in Canada, a variation of the first stage is also being employed to derive oil in that country.

Oil in commercial quantity was discovered for the first time in 1859 when 'Col' Drake struck oil in his first well in Titusville, Pennsylvania. The well drilled by the cable tool method was a shallow one, being 160 feet only, and spurted a drive for searching oil in the vicinity of oil seepages.

Once the relationship of oil to structure was established, the prospectors changed their venues of exploration to areas where surface geology established anticlines. This resulted in the discovery of oil pools in various parts of America and the rest of the world in the late 19th and early part of the 20th century. Spectacular success was met with in California and Texas.

In southern United States, association of oil with salt domes in the mid-thirties opened up a new phase, and led to the discovery of some of the largest oil fields in the world.

Relationship of oil to stratigraphic traps was recognised by the exploration geologists more than two decades back. Such traps may be formed by pinch outs, lenses, secondary increase in porosity in limestone and reef by dolomitisation.

In Canada at the end of 1948, oil exploration was virtually coming to an end when a chance discovery of oil in the Devonian reefs was made in the Leduc area. This discovery revealed the association of oil with the dolomitc coralline reefs and it spurted a drive for these reefs elsewhere in western Canada. Facies and regional structural studies carried out in the laboratories led to the discovery of oil in the Cretaceous Pembina Sandstone and Granite-Wash discoveries in Central and Northern Alberta.

These successes were not results of guess work but the crowning of the painstaking efforts made by the research geologist. The data collected from surface geology and the innumerable wild cats was plotted and maps were made to delineate the geography in the geological past. On these paleogeographic maps, the shore lines of the ancient seas were traced and the possible locii of the reefs were demarcated.

In Pakistan, since the later part of the 19th century oil has been searched for by numerous oil companies. Initially the exploration was restricted to areas around seepages. Success upto a certain measure was achieved in Khattan in Baluchistan where over 25,000 barrels of oil were produced from 13 wells. In Fatehjung, south of Cambellpur, oil measurable in tens of barrels only was produced from one well. However in both the instances mentioned above, production ceased in a short time.

After the discovery of oil in Khaur, Dhulian in the Potwar Plateau, systematic field surveys revealed other potential anticilinal structures, and after 1949, when the new rules and regulations promulgated by the government of Pakistan came into force, intensive search was undertaken by more than ten oil companies. Over 100 wells have been spudded in since 1949 and thousands of feet of sediments have been drilled through. Alas, the results on these anticlinal traps have been rather disappointing, and the discoveries of oil have been confined to the Potwar region only.

However, the abandoned wild-cats have given us a ray of hope. "Dead" oil was found in Pakistan Shell Oil Co., Karampur—1 in the Multan District. Again in Dhulian field, the Jurassic discovery in 1960 established a relationship of oil to the facies, the sand is productive in the west but towards the east in the same field, facies changes occur and the producing horizons are impermeable.

For further details about the history of oil exploration in Pakistan, the excellent review by Majeed (1966) may be consulted.

*Future exploration.*

It must be pointed out at the onset that every wildcat, even if dry, yields important information for future exploration. All records should be kept, and maintained for future reference. The petroleum geologist is continuously gaining knowledge from both his success and failures and from the scientific advances in the field of exploration. New fields have been found in regions which had been declared unprospective earlier when the knowledge and quality of equipment were both limited.

Research in the present day sediments as well ancient ones have shown that oil is often associated with reefs, particularly biohermal types. Oil has been discovered in commercial quantities from such reefoid masses from the Ordovician bryozoan reefs in New York and Pennsylvania, Silurian reefs in Ontario, Devonian $D_1$ $D_2$ and $D_3$ reefs in Western Canada, and the Permian Guadalupian Formation in southern United States. It is quite possible that Mesozoic and Tertiary reefs would also form good reservoirs if the geological conditions are favorable.

Reefs, as the research on modern sediments shows, occur in shallow warm water conditions. There are, however, exceptions to this rule as coral reefs are found close to arctic circle (Teichert, 1966). Reefs form one type of stratigraphic trap. Pinchouts are formed close to the shore lines as well in the regions adjoining cratonic masses. Similarly lenticular formation is not uncommon feature in shallow water conditions.

To locate reefs, pinchouts and lenses, it is therefore imperative to establish the shoreline configuration in the geologic past and to establish the environmental conditions. The former is represented by paleogeographic maps and the latter by lithofacies maps. Again isopach maps based on thicknesses of formations in each geological period under review supplements the information represented in above two types of maps.

In Pakistan, as mentioned earlier, oil search has been concentrated on structural traps. Discovery of oil in 1960 in the Jurassic sediments and its relationship to facies change within the Jurassic clearly establishes the imporance of stratigraphic traps (Day 1962).

From the data available the present writer prepared lithofacies maps, isopach and paleogeographic for Triassic, Jurassic, Cretaceous, Paleocene, Eocene and Oligocene. Data for these maps were obtained from the various oil companies and the author gratefully acknowledges the cooperation of the companies and the Geogical Survey of Pakistan for the use of their material. The present author, however, assumes entire responsilility for the time and lithological boundaries.

It may be pointed out that the maps are still in their preliminary stages as the stratigraphic sections and the subsurface are too widespread for accurate delineation of bundaries. As and when more information is made available, these maps will be revised.

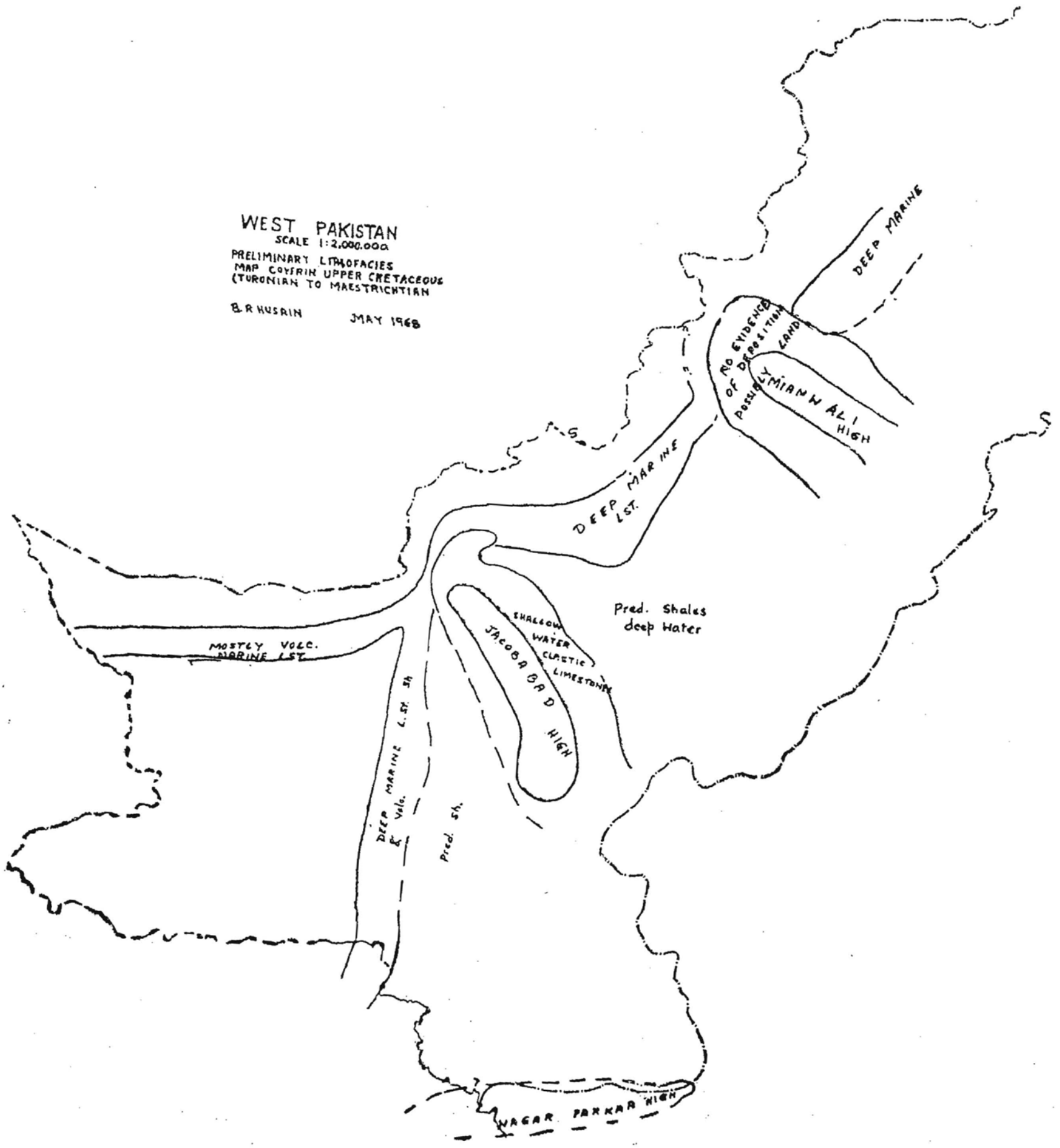
During the Triassic (Encl. No. 1) deep sea conditions prevailed over the Sulaiman Region but near the Mianwali re-entrant, shallow water conditions prevailed and breaks in sedimentation occurred in Khisor Range (Husain, 1960). In the immediate north, in the Khisor Range, Sor Range and the Punjab Salt Range, shallow water and neritic condition prevailed with the deposition of the Kattikiara sandstone, Kingriali Dolomites. Local disconformity was established in the Nammal Gorge and Dhak Pass area at the top of the Kingriali Dolomite with evidence of sub aerial exposure and erosion (Voskorsensky, 1964). Still further north in the Kalla Chitta Hills, the stratigraphic succession in the Triassic indicates deep water conditions prevailed and the rocks are more related to those found in Spiti area than the Salt Range suecession.

# WEST PAKISTAN

SCALE 1:2,000,000

PRELIMINARY LITHOFACIES MAP COYERIN UPPER CRETACEOUS (TURONIAN TO MAESTRICHTIAN

B.R HUSAIN MAY 1968



It seems therefore that the paleogeographic and lithofacies maps can establish the environmental conditions during the Triassic. The Kattikara Sandstone as discussed by the author in another paper can possibly form good reservoirs if the source rock for oil is Permain (Hussain 1964).

A similar pattern is obtained for the Jurassic and Cretaceous periods. ( Encls. 1 and 2). However, in the latter, the uplift of the Sibi-Quetta Re-entrant changes the ancient physiographic picture considerably. The influence of this re-entrant is manifested by the appearance of Maestrichtian limestones close to the buried Pre-Cambrian massif while further away from it, the marine shales are extensively developed.

Further south near the Nager Parkar basement, the sedimentation north and south of the Pre-Cambrian massif was quite different: Marine sedimentation was going on in the Sind area whereas extensive sub aerial lavas were being poured out in the Cutch-Cambay- Angleshwar area as shown by Poddar (1962).

During the early Tertiary, the formations in the Potwar were deposited in fairly deep sea conditions; they are entirely absent in the Khisor-Marwat Ranges (Hussain, 1960), marine limestones and shales in the eastern part of the Sulaiman Ranges. Towards west near Quetta and south near Sui, neritic limestones are developed. Further south in Sind area, sandstones with coal seams indicate shallow water to lagoonal conditions in the Lower Paleocene becoming neritic in Upper Paleocene to Eocene.

The Oligocene lithofacies map gives very interesting results. In Sind area remarkable facies with in the Nari Formation have been noted. Near Sui-Sibi Re-entrant area, the formation consists of sandstone with vertebrate fossils. Near Karachi and immediately north of it reefoid masses are extremely common. Thus both Karachi and Bugti were possibly near the shores of the Oligocene sea.

North of Sui, shallow water conditions prevailed upto Fort Sandeman and later a marine facies was developed with rocks containing pelegic foraminifera.

North of the Mianwali Re-entrant, the Oligocene is represented by shallow water deposits with vertebrate fossils in one locality (M.H.Khan, 1956).

The author wishes to point that the above discussions on the maps had to be made brief for want of space, and also due to the fact that the maps are tentative.

It appears therefore that once the ancient physiography and environmental conditions are established, it will be possible to delineate areas of possible reefs. Again, near the re-entrant areas which have been active in different periods, (Husain, 1967,) pinchouts and lenses can form. Such areas of the re-entrants can also be shown on the paleogeoraphic maps depending upon the effects on the sedimentation by these cratonic massifs.

*Conclusions*

1. Oil exploration in any country is not complete unless stratigraphic traps are also examined and evaluated.

2. In Pakistan, we are on the brink of the 3rd stage in oil exploration namely the stratigraphic traps.

3. Extensive areas of sedimentary cover exist in Pakistan where drilling has not been done even for stratigraphic information.

4. Paleogeographic and lithofacies maps of Pakistan based on the scanty in formation from the widely spread surface section and subsurface logs outline the ancient shore lines and the cratonic masses.

5. Reefs are known to occur near the south western shore of the Oligocene sea. Detailed research along these lines may also produce similar results from other geologic periods.

6. Paleogeographic and the related lithofacies maps have helped successfully in the search for oil in other parts of the world and we in Pakistan may well utilise this technique in our quest for oil.

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# WEST PAKISTAN

SCALE 1:2,000,000

PRELIMINARY LITHO-FACIES MAP OF TRIASSIC

B.E. HASAIN MAY 1968.

DEEP MARINE Lst. Sh.

SHALLOW WATER Sst. Dolo.

DEEP MARINE Lst. Sh.