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Evaluation for Hydrocarbon Potential of Volcanic Rocks in Southern Sindh

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INTRODUCTION

There is a big subsurface area in southern Sindh occupied mainly by the volcanic rocks. They are said to be stratigraphically equivalent and lithologically similar to the Deccan Traps. The area of their occurrence in the southern part of Lower Indus Basin is spread over 30,000 sq. Km (Figure 1). The range of their thickness is upto 300 m. A number of articles have been published about the geology of Deccan Traps and their associated rocks in Sindh.

Occurrence of commercial hydrocarbon deposits in volcanic rocks are reported from many parts of the world, for example, the famous Rattle Snake Hills oil field of Washington U.S.A. (Levorsen, 1967). This led the authors to investigate volcanics of Sindh.

MODE OF GEOLOGICAL INVESTIGATION

The Strato-Structural setting along with other geological features of the volcanics and their associated rocks have examined to evaluate their oil and gas potential. For this purpose study of their lateral and vertical extent from well logs and surface exposures has been made. Examination of lithological characters, and the general correlation in different wells have also been made. The well data can provide a limited information on the lithological and the reservoir characteristics of the volcanic rocks, therefore, the exposures of the volcanic bodies in the Laki and the Kirthar Ranges were examined in the field. In addition the exposures of Bela volcanics which are said to be marine equivalent of Deccan Traps or fissure eruptions were also examined for their lithology, structuration, fracturation and fissuration.

The description of the factors, needed to asses the hydrocarbon potential of the volcanics were examined in the field and also studied with the help of previous data, as given below:

EXTENT OF THE VOLCANIC ROCKS IN THE BASIN

The volcanic rocks of the uppermost Cretaceous to Paleocene age have been encountered so far in the wells drilled in the Lower Indus Basin south of Sukkur and Khairpur areas of Sindh extending down to the offshore area. The area of their extent is approximately 30,000 sq. Km (Figure 1).

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The maximum thickness is upto 300m. This estimate is based on geological and geophysical evidences. The volcanics of Sindh are an extension of the Deccan Traps of India into the Lower Indus Basin of Southern Sindh. The volcanic sheets are intercalated with sediments but total thickness is believed to be ranging up to 300m in offshore area in the southwest (Kadri and Khan, 1973).

GENERAL GEOLOGICAL ASPECTS

The data gathered from surface and subsurface when interpreted within the regional tectonic framework revealed the following information. It is for speculation regarding the general trend of the development of petrophysical characters on which mainly depends the petroleum prospects of such volcanics.

I. Tectonic Setting of the Volcanic Zone of Southern Sindh

The volcanic zone is situated in the southern Sindh, west of which two tectonic trends pass across each other. The one which in general runs NS can be called the Kirthar trend. The other is a mild superimposed one running east-west with its axis passing almost over Thatta region (Figure 2). This is the zone of the maximum structuration in the form of folds and faults along with the development of various kinds of minor secondary structures.

II. Strato-Structural Setting of the Volcanic Rocks

The volcanics which are mainly basalt are sheet-like tapering bodies formed by intermittent fissure eruptions. At many places they are arranged one above the other having the shale, sandstone and limestone as intercalations (Figure 3). In the borehole, drilled by the Burma Oil Company in 1950 in Lakhra (Burma Oil Company, 1950), District Dadu (Krishnam, 1982), a basalt flow 15m thick was encountered below the lower Ranikot bed at a depth of 775m. This was followed below by 45m of sandstone and shale: 25m of basalt: and sediments with traces of basalt for further 75m (Figure 3). The stratigraphic setting of sediments and volcanics in other boreholes in the basin are similar. Layers of reworked volcanic rocks are also found associated with sediments. As the volcanics occur as sheet or beds of variable thickness they behaved like the stratified sediments during the flexuring. They

Modified after subsurface occurence of volcanic rocks in Southern Sindh and offshore area.
I.B. Kadri & J.M. Khan., Geonews, G.S.P (1973) & OGDC (1991).

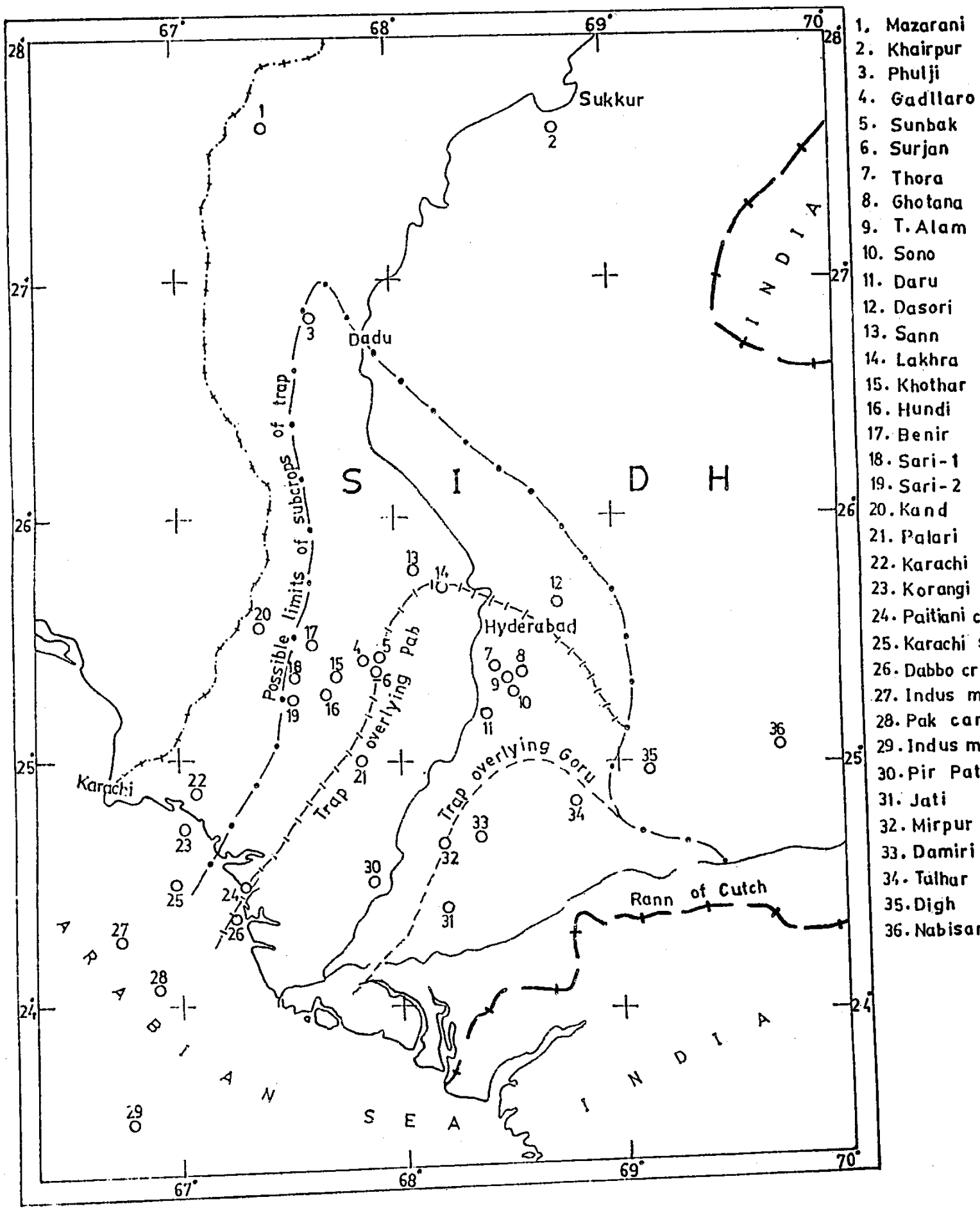

Figure 1- Map showing limits of volcanic rocks and the location of the wells drilled.

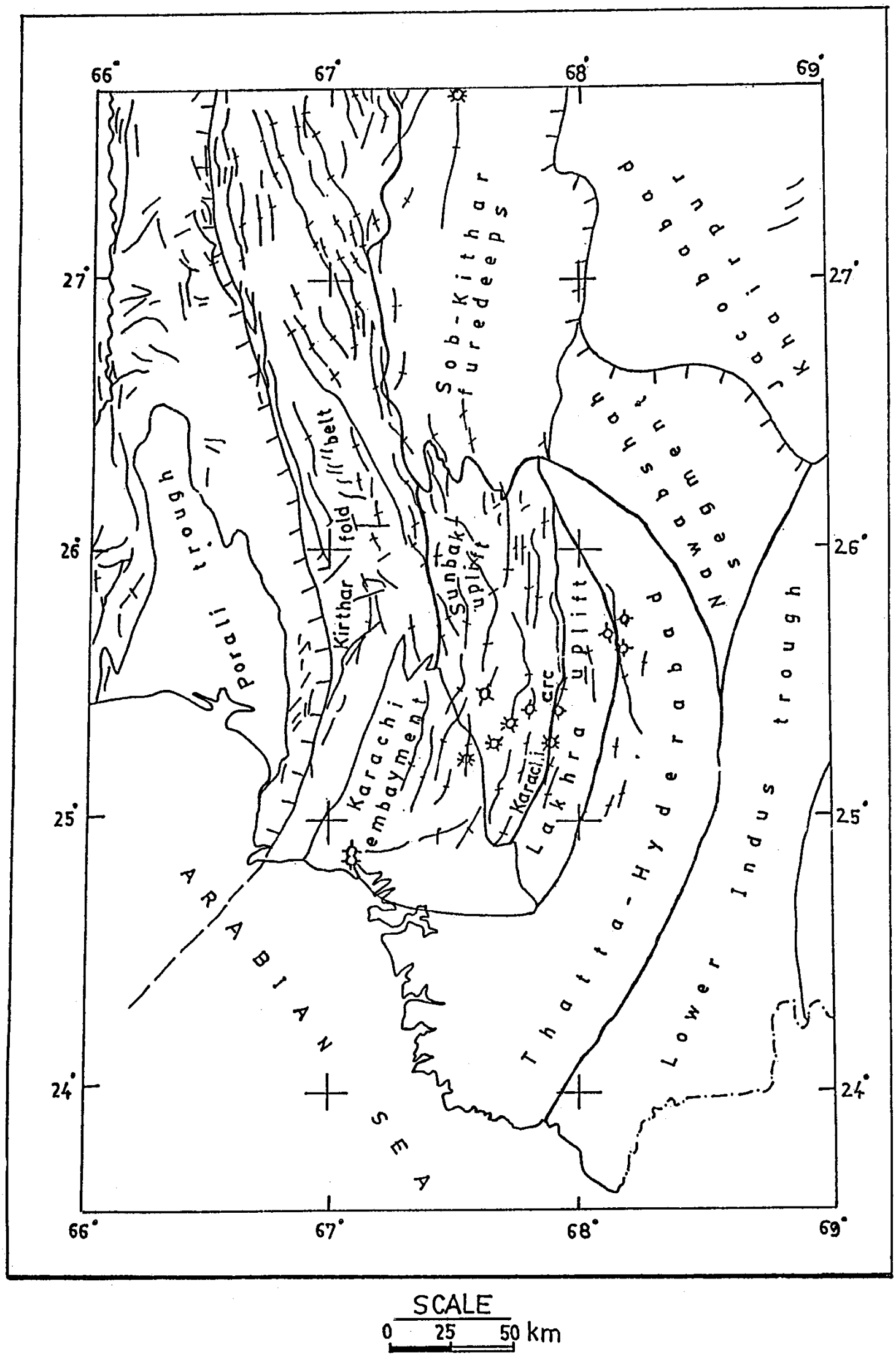

Figure 2- Tectonic and structural map of southern Lower Indus Basin showing two trends of folding i.e. Kirthar Axis & Karachi Arc.

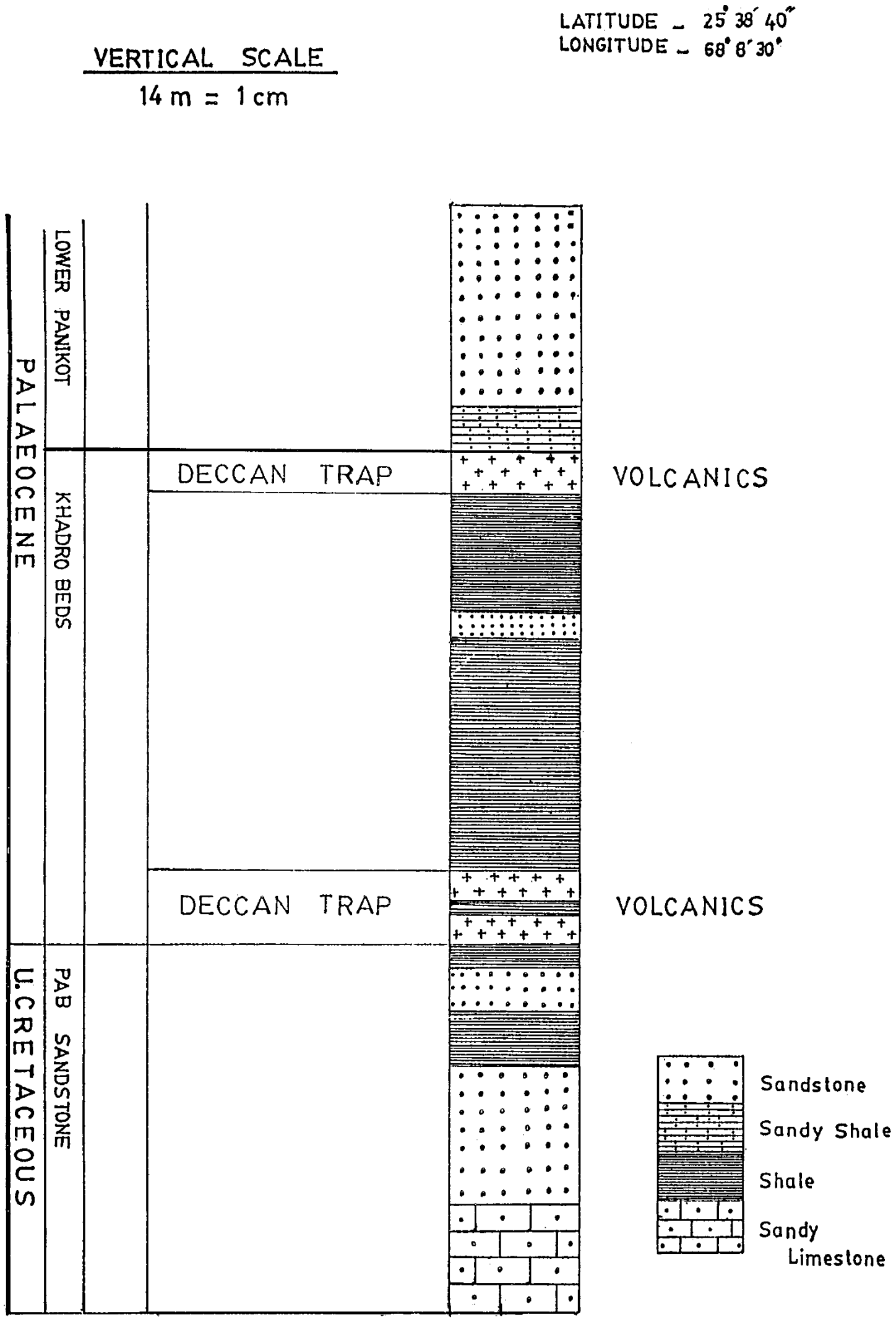

Figure 3- Well log showing volcanics and intertrappean beds in Lakhra area (Lakhra Well No.1).

are the subaerial eruption which have followed the pre-existing topography of the depositional surface.

The flows have great lateral extent in comparison with their thickness. In Laki Range the volcanic sheets in places are exposed on the surface (Hunting Survey Corporation, 1961). They are affected by the flexuring, fracturing and fissuring.

III. Lithological Features of the Volcanic Rocks in Sindh

Beside the examination of the lithology of the volcanics from the boreholes, it was also investigated in the surface exposures of Laki Range. The Bela volcanics which are sub-marine equivalent of Sindh volcanics are also examined in surface exposures for lithological comparison. The well cuttings and the surface exposures show the rocks to be basalt or dolorite. On the upper part of the volcanic flows vesicles, vugs, and cavities are seen, some of which are connected by the Joints and cleavage are seen. The basalt on fresh as well as weathered surface is of various tints of green, dark green, brownish green and grayish green. At places it has reworked layers of volcanics mixed with sediments.

RESERVOIR CHARACTERISTICS OF VOLCANIC ROCKS

The igneous rocks especially the basalts are considered generally to have poor reservoir characteristics. However, when they come under enough flexuring, fracturing, fissuring, weathering and reworking they develop sufficient secondary porosity and permeability to produce hydrocarbons. There are many examples of production from basalt and pyroclasts reservoir such as the basalt reservoir of Rawesnarhr field of Washington U.S.A. and tuff reservoir of Samgori Field of Republic of Georgia (Grynberg et. al. 1993). Many more fields have been discovered throughout the world in the igneous rocks during the last twenty years. Thus the volcanic bodies of the Lower Indus Basin in the southern Sindh in the zone of appreciable orogeny (Figure 2) may have developed good reservoir quality and become receptive to the hydrocarbons at least in those zones where they are suitably fractured and fissured, weathered and reworked. The induced porosity and permeability in combination with vesicles, vugs and cavities and fissures might have rendered the volcanics to be a productive reservoir.

The reservoir characteristics of the intercalated sandstone, it is contemplated, might also increased by the combination of the primary and induced secondary porosity.

INDICATION OF HYDROCARBON IN THE VOLCANICS

The volcanic reservoirs in Sindh like most of the other Cretaceous and Paleocene reservoirs should be sourced from the Cretaceous Sember and Goru shales. The indication of the hydrocarbon has been met in the form of shows of oil and gas from the volcanics in the wells, for example, in the Union Texas Co. Well Tarai no. 1 (Union Texas Pakistan Inc., 1979).

RESULTS AND DISCUSSION

A big volume of volcanic complex approximately 9000 sq. km. both on the shore and the offshore of southern Sindh is available for exploration. However, the wells drilled in the zone of the volcanics so far do not give an encouraging result in the form of a commercial pool. It seems that a greater part of the volcanic zone which has the possibility of developing the productive porosity for hydrocarbons has not been properly explored. It requires a study of the tectonic setting and reworking in the volcanic area to delineate and to develop concept about porosity and permeability trends in them.

There are examples in the world that basalts are reservoir where properly fractured. Thus, using factors that induce and enhance the porosity, an attempt should be made to delineate the suitable zone in the volcanics for further study for exploration (Figure 4). The volcanic flows follow the pre-existing topography of the depositional surface. The subaerial weathering that follows would fracture, erode and rework the volcanic material and deposit it on the slope of the high in the way depicted in Figure 5.

CONCLUSIONS

The study of the geology of the volcanics and the associated rocks for hydrocarbon potential does present a fair situation. It is by virtue of their favorable tectonic setting in some parts of Southern Sindh and the suitable Strato-Structural position, that the chance of development of zones of weathering and reworking under sub-aerial condition have developed. Also possibility of the enhancement of their porosity by secondary processes and the direct evidence for the occurrence of hydrocarbons encourage their exploration.

It is, therefore, recommended that in the southwestern area (Figure 2) exploration may be made for hydrocarbons. Initially some wells for the exploration of the primary horizons. in the prospective structure should be located. It should be in such a way that volcanic bodies may also be explored side by side by picking up a "compromised" location among the prospective horizons, as for example, shown in the (Figure 5).

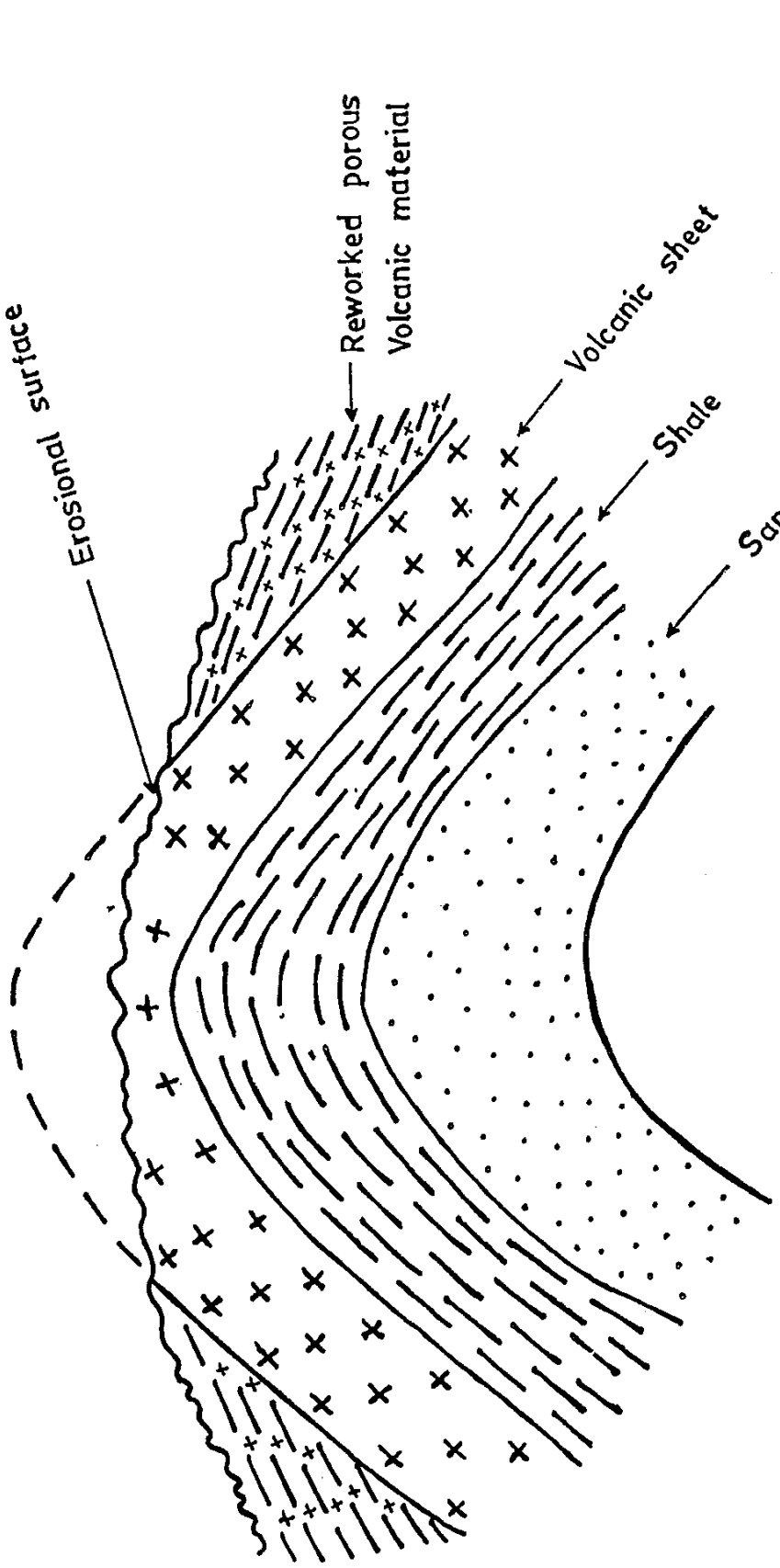

Figure 4- Diagrammatic sketch showing pre-burial subaerial erosion and reworking of the volcanic rocks in Southern Sindh.

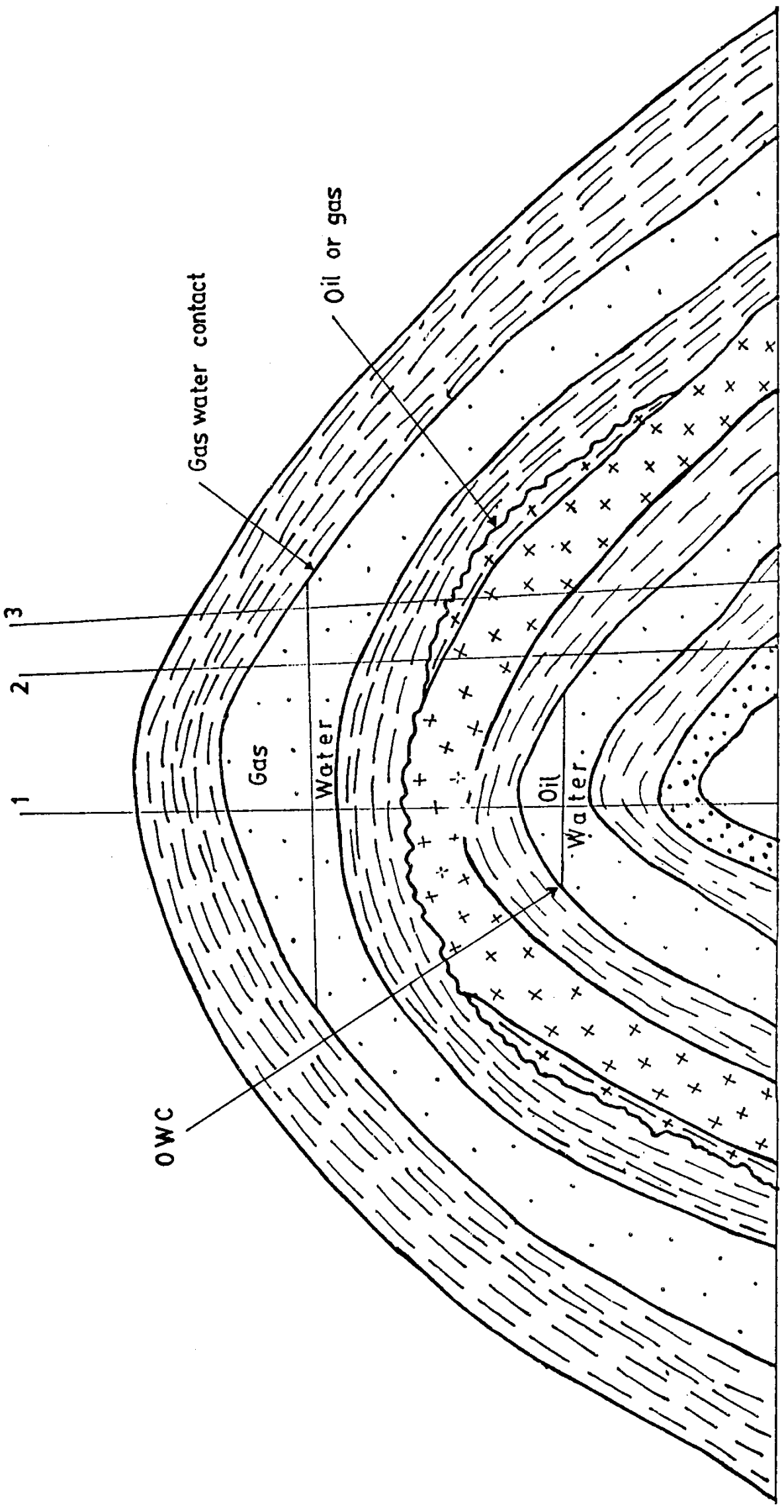

Figure 5- Diagrammatic section illustrating the location of a well-3 to check the limit of gas pool. The sequence of the well is also shown by numbers.

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