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Surface geochemical survey data evaluation and integration with seismic data for hydrocarbon prospectivity in west of Baola Area, Ahmedabad Block, Cambay Basin, India

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Abstract

Surface adsorbed gas survey aims toward risk reduction in exploration by identifying the hydrocarbon prospective areas on the basis of near surface hydrocarbon identification and integrating with geology of the area. The present investigation aims to explore potential petroleum areas in West of Baola area, part of known petroliferous Cambay Basin.

Results indicate 677 ppb, 450 ppb, 275 ppb, 201 ppb, 137 ppb and 39 ppb maximum concentrations of C_1, C_2, C_3, C_4, C_5 and C_6 respectively. The survey indicates presence of subsurface hydrocarbon charge not influenced by secondary effects during migration and adsorption on sub-surface soil.

Four positive anomalies have been identified and ranked based on anomalous concentration of propane. It is observed that the west-central part of the study area shows highly anomalous concentration of surface hydrocarbons followed by north-eastern part (NW) of Baola Field.

Integration of geochemical anomalies with seismic data reveals that these anomalies are prominent in the area where high amplitude reflections are seen within Mesozoic sediments (indicating possible presence of reservoir facies). Anomalies-I, II and IV might have seeped from Mesozoic sediments where relatively lesser thickness of Trap might have facilitated hydrocarbon migration. However, hydrocarbon generation by Mesozoic sediments is yet to be established in study area.

Anomaly-II is probably related with occurrence of syn-rift Tertiary sediments in the area as brought out by a seismic inline passing over the anomaly.

Key Words: West of Baola area, Adsorbed gas survey, Propane, HC Prospectivity.

Introduction

Surface Geochemical Survey is tool for hydrocarbon exploration based on the principle that hydrocarbons generated are seeped to the surface from subsurface through micro fractures/micro pores by the mechanisms of diffusion, effusion, and buoyancy. These Micro seepages of hydrocarbon gases retained in the soil sediments and often interpreted as a direct indication of the presence of deeper hydrocarbons.

This paper describes the application of surface geochemical studies carried out in West of Baola area Ahmedabad-Cambay-Tarapur Block, WON Basin for the prospecting of hydrocarbons. A total of 2197 soil samples were collected for the study in the grid of 500*500m in 606.80 sq Km area.

The region has received wide attention as it is less explored from hydrocarbon point of view. Hence an attempt has been made to find the presence of hydrocarbons in the Tertiary as well as Mesozoic sediments in the study area.

Geology of the study area

The study area is located on the western rising flank of Ahmedabad block of Cambay Basin. Oil and gas producing fields like Sanand and Baola are located in the North East & East of the block respectively (Figure-1& 2).

This area is part of two different type of depositional system in two different eras. Older one is depositional system in Mesozoic era and younger one is sedimentary system of Cenozoic era. This Cenozoic era depositional system is very well understood in the area. Large number of wells data, seismic data and passive source data have distinctively described the entire basin from its evolution to its filling and its tertiary petroleum system. At the Mesozoic level, basin is very less understood due to sparse data, limited number of seismic data (specially focused for imaging below basalt).

Precambrian rocks of Aravalli System are exposed in the northern part of the Basin. Deccan Traps of Upper Cretaceous age is exposed on the eastern and western flanks of the Basin. Mesozoic sediments underlie the Traps and are the earliest-formed sediments over the Basement.

They are exposed outside the Basin near its eastern and western margins. A thick sequence of sedimentary rocks ranging in the age from Paleocene to Recent overlies the Deccan Trap, which is considered as the technical basement in Cambay Basin for Cenozoic deposition.

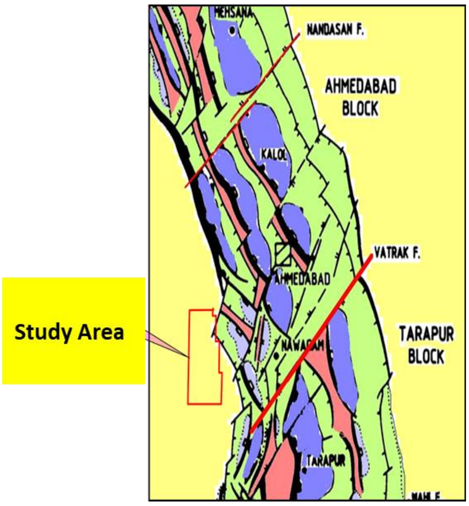

Fig-1: Location map of Study area

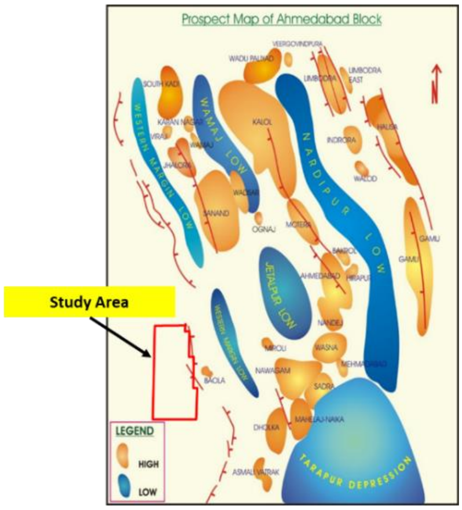

Fig-2: Prospect map of Ahmedabad Block, Cambay Basin Showing Study area

Materials & Methodology

The adsorbed soil gas samples were collected from dry holes of 5 meter depth and coring (20 cm x 5 cm) was done using core catcher. Collected soil core samples were processed for homogeneity and sieved. The fine grained portions (<150 µ) were subjected to ortho-phosphoric acid treatment under vacuum in specially designed glass desorber assembly to release the adsorbed hydrocarbon gases. Carbon dioxide gas co-released with lighter hydrocarbon gases during the ortho- phosphoric acid treatment was absorbed by KOH solution in the glass desorber assembly. Hydrocarbons in the desorbed gases were analysed for their light hydrocarbon content by Agilent-7890A gas chromatograph using flame ionization detector and 25% DC- 200 packed column.

Concentration values of individual hydrocarbons from methane through hexane are expressed in parts per billion (ppb) by weight on dry basis (Chandra K. and Gupta M.C., 1973). Data was processed to analyse the distribution patterns of different hydrocarbons (C1 to C6) and to determine various ratios for genetic correlations. The characteristic background mean and standard deviation values were determined by using iterative elimination of anomalous values (Saunders D.F., 1989).

Interpretations and Discussions

Presence of hydrocarbons up to hexane (table-1) indicates that micro seepages of hydrocarbons are of thermogenic origin and a trend of decrease in concentration from methane to hexane C1>C2>C3>C4>C5>C6 is characteristic of gases from petroliferous origin (Dickinson R.G. & Mathews M.D., 1993).

S.N.	Component	Concentration range (ppb)		% Distribution in Samples
		Min	Max	
1.	Methane (C1)	0.23	677	100
2.	Ethane (C2)	0.04	450	100
3.	Propane (C3)	0.04	275	100
4.	Butane (C4)	0.00	201	98.45
5.	Pentane (C5)	0.00	137	91.71
6.	Hexane (C6)	0.00	39	59.89

Table-1: Hydrocarbon Distribution in West of Baola Area

The histograms of all the HC components shows positive skewness which means that mass of the distribution is concentrated on the left of the figure and has relatively few high values. These characteristics are commonly observed for hydrocarbon gases derived from petroliferous area (Tedsco S.A., 1995).

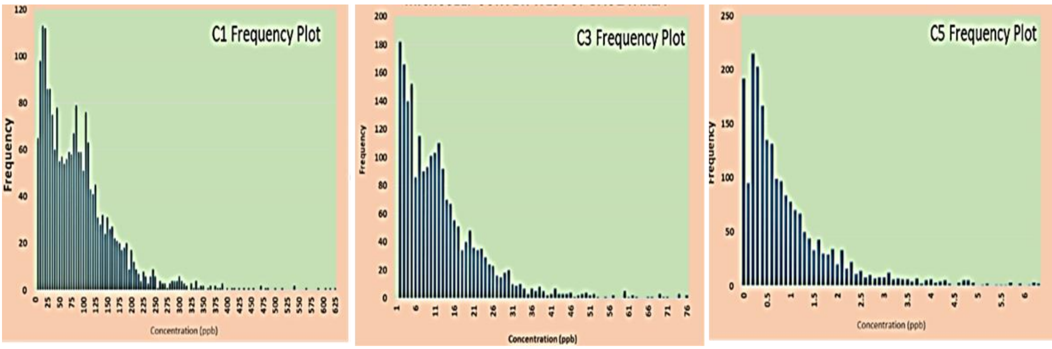

Figure-3: Frequency distribution patterns for hydrocarbon concentration of C1 to C6

The use of various hydrocarbon ratios in data evaluation was developed as a way (i) to predict the type of petroleum present at depth (wet gas, dry gas or oil) and as a filter to eliminate false indications of anomalous conditions (Yasnev B.P., 1986) (ii) to obtain an idea about the nature of hydrocarbon in the sub surface pools from where they seep to surface (Bernard B.B. 1977). Table-2 shows ratios of various hydrocarbon constituents which indicates that the subsurface pool likely contains oil in the study area.

Composition	**(C1/ ΣC1-C4)*100**	**C1/C2**	**(C3/C1)*1000**	**C2/C3**
Dry Gas	95 – 100	20-100	2 - 20	4 - 6
Gas Condensate/ Oil & Gas	75 – 95	10-20	20 - 60	2.5 - 4
Oil	55 – 75	4-10	60 - 500	1 - 2.5
Average Ratios in the study area	69.39	4.54	168.38	2.07

Table-2: Approximate Empirical Range of Microseep Compositional Ratios for Gas, Gas condensate, and Oil (from Jones and Drozd, 1983, Schumacher 2003)

Some more ratios were calculated in the study area. 72.18% samples shows C2/C3+ ratio <1.3 (Nikonov, 1961) and 99.94% samples shows C1/ΣC1–C6 ratio <0.97 (Faber, 1984) which indicates catagenetic origin of the microseeps and association with liquid hydrocarbon.

The cross plots of all constituents of seeped hydrocarbon gas follow a linear trend which suggests theromogenic origin of microseeps, sourced and migrated under the same conditions and are associated with oil & gas. Cross plot of wet gas% (C2-C6/C1-C6*100) vs. total gas (C1–C6) supports the thermogenic origin of the microseeps (Abrahms M.A., 2001).

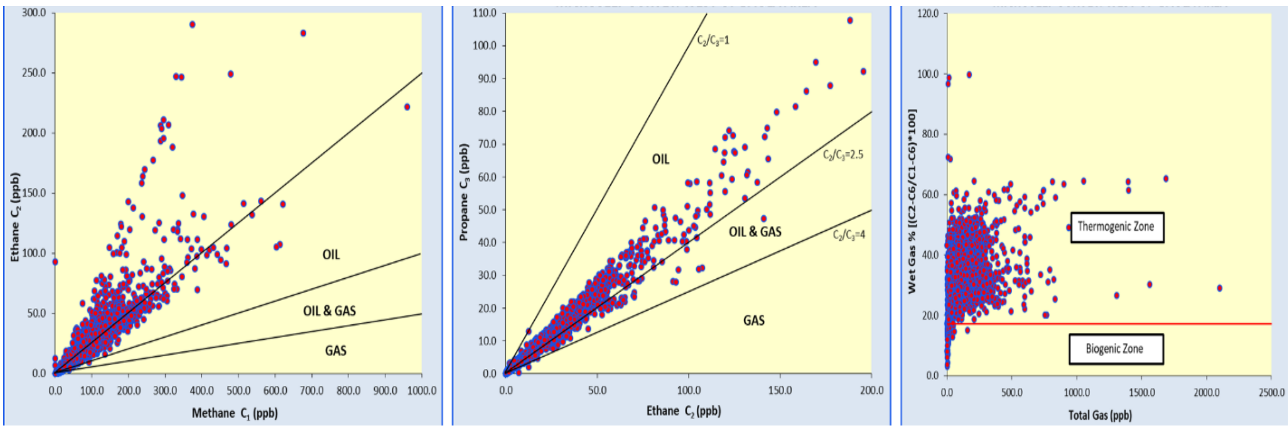

Figure-3 (a): Cross plots of C1 vs. C2 and C2 vs. C3, 3 (b) Cross plots of Total Gas vs. Wet Gas

The linear relationship of logarithmic concentrations of all constituents in adsorbed gases suggests that microseeps have not undergone any prominent secondary alterations such as biodegradation, degassing and bacterial activity during upward migration from the subsurface to the surface and their subsequent adsorption on the soil.

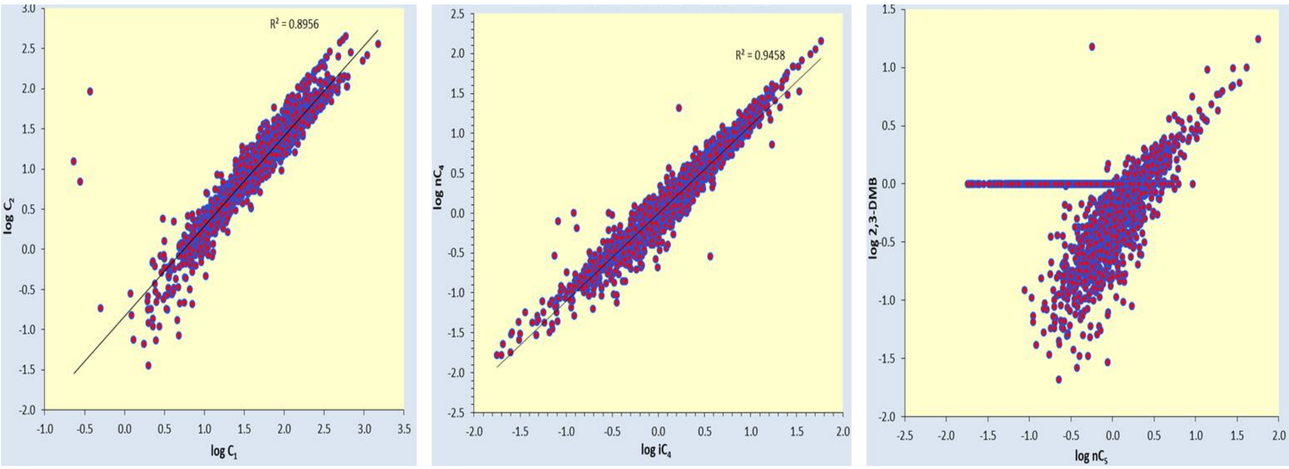

Figure-4: Cross plots of logarithmic concentrations of various constituents of hydrocarbon gas

For delineation of prospective areas in the studied block, contouring of concentrations of all the hydrocarbon constituents (methane through hexane) is being done using Petrel Software. Since propane is considered as more reliable indicator, the anomaly map of propane (Figure-5) has been used for evaluation of anomalies.

The study indicates presence of four prominent positive hydrocarbon anomalies in the following order:

- Baldana-Devdholera anomaly (A-I)
- Vasna- Dedhal anomaly (A-II)
- Kanotar anomaly (A-III)
- Govinda-Rethal anomaly (A-IV)

It is observed that the west-central part of the study area shows highly anomalous concentration of surface hydrocarbons followed by north-eastern part (NW of Baola Field). Northern, southern and eastern parts are nearly devoid of hydrocarbon anomalies.

Surface geochemical anomalies have been integrated with seismic data to find out the relation between surface anomalies with subsurface geological features. Figure-6 to 9 are showing seismo-geological sections passing through all the four anomalies.

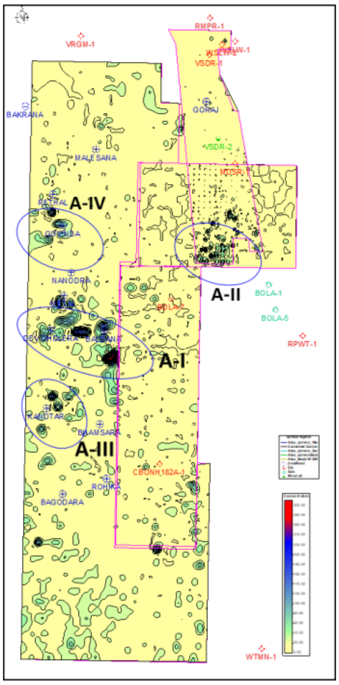

Figure-5: Propane (C-3) anomaly map showing four positive anomalies

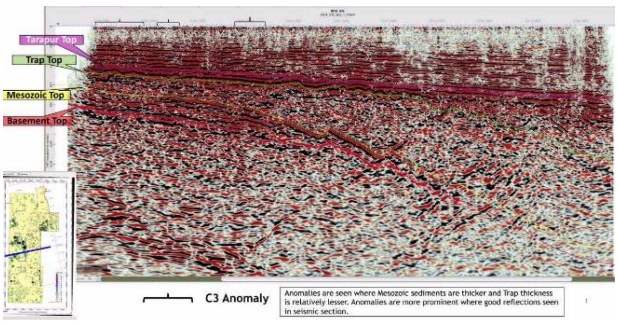

Figure-6: E-W Seismic section passing through A-I & A-III anomalies

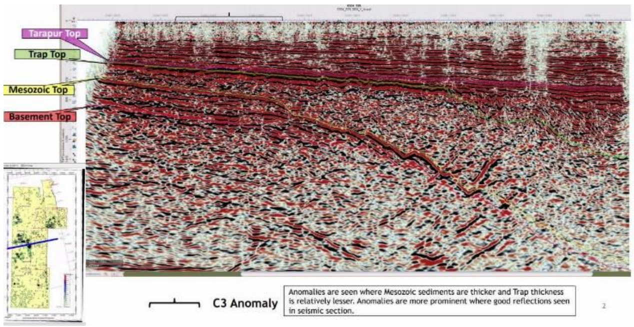

Figure-7: E-W Seismic section passing through A-I anomaly

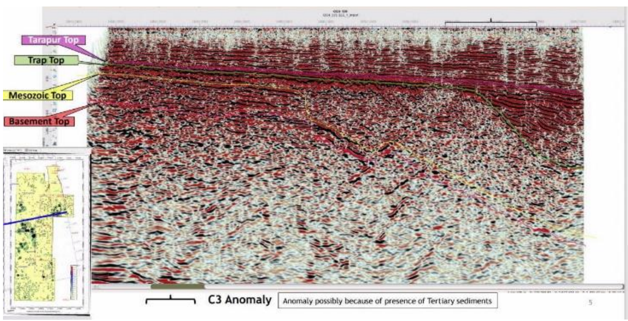

Figure-8: E-W Seismic section passing through A-II anomaly

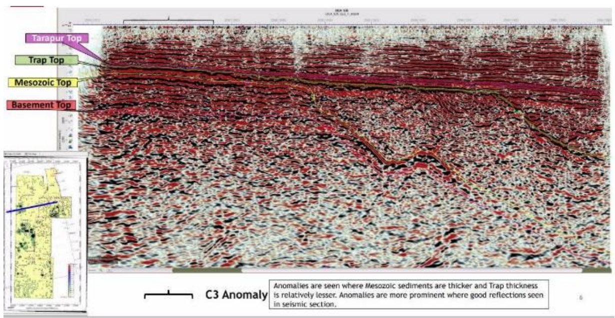

Figure-8: E-W Seismic section passing through A-IV anomaly

Anomalies-I, II and IV are located in the western part of the area where thickness of Mesozoic sediments are relatively high and thickness of Trap is relatively less as revealed by seismic data. Lesser thickness of Trap might have facilitated hydrocarbon migration in overlying sediments. These anomalies are prominent in the area where high amplitude reflections are seen within Mesozoic sediments (indicating possible presence of reservoir facies). Anomaly-II (NW of Baola Field) is probably related with occurrence of syn-rift Tertiary sediments in the area as brought out by a seismic inline passing over the anomaly.

1D Petroleum System Modeling was carried out at a Pseudo well point in the deepest part in vicinity of the study area. From the PSM, it is clearly seen that the entire Mesozoic sequence is within the hydrocarbon generation window (Late oil to wet gas) but paucity of source sequences within Mesozoic section is a major risk for hydrocarbon prospectivity for Mesozoics in the area.

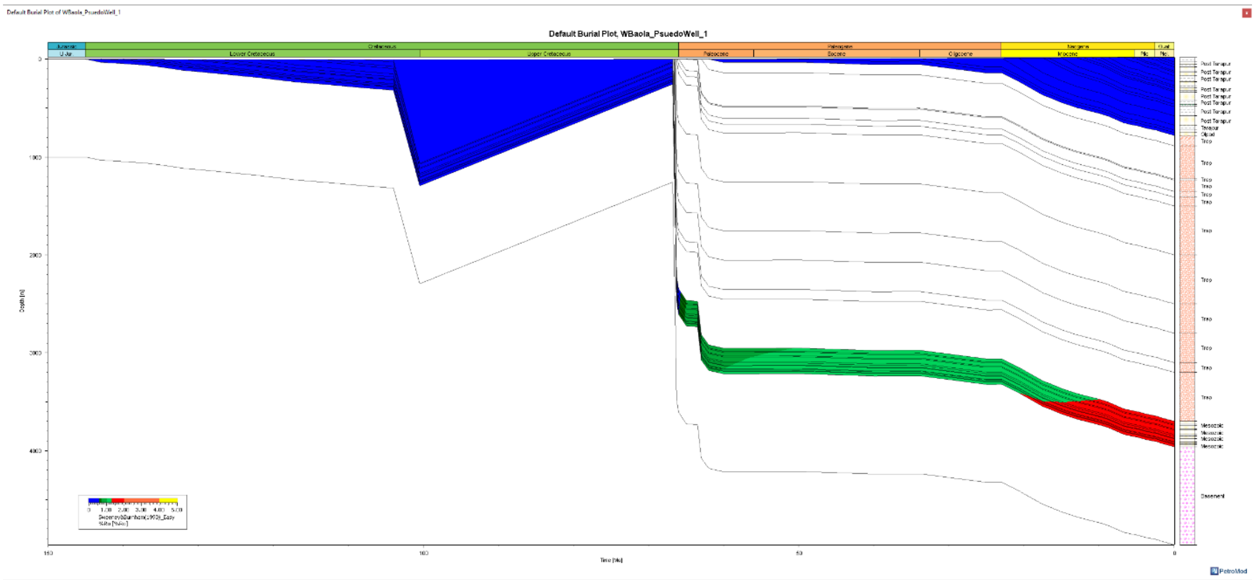

Figure-9: 1D petroleum system modelling at pseudo well location in the deepest part near to the study area

Conclusions

This survey indicates presence of subsurface hydrocarbon charge not influenced by secondary effects during migration and adsorption on sub-surface soil.

The study indicates presence of four prominent positive hydrocarbon anomalies in the following order:

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Anomaly-II (NW of Baola Field) is probably related with occurrence of syn-rift Tertiary sediments (Olpad) in the area as brought out by a seismic inline passing over the anomaly.

The results of present study will help in identifying prospective areas for hydrocarbon exploration, especially in Mesozoic sediments, in this part of the basin.

Acknowledgements

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