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Surface geochemical prospecting by adsorbed gas survey in South Gamijfield,Cambay basin.

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Abstract

Surface geochemical prospecting of hydrocarbons is the search for invisible near surface expressions of hydrocarbons, which could indicate the occurrence of petroleum accumulations in the subsurface. Geochemical prospecting is a cost effective method to delineate prospective areas, helps in prioritising areas for further exploration and can also be used to improve exploration efficiency by prioritising prospects.

The hydrocarbons that are generated and trapped in the subsurface reservoirs seep towards the shallow surface due to imperfect reservoir seals, leading to surface hydrocarbon anomalies. The low concentration of the migrated hydrocarbons can be chemically detected using sensitive analytical tool.Byusing appropriate statistical tools, hydrocarbon data can be contoured to provide high and low probability areas and can be reliably correlated with the hydrocarbons present at depth by integrating with G & G inputs.South Gamij field,in Eastern Basin Margin of Cambay Basinis a less explored area. Adsorbed gas studies have been carried out to help in identifying areas prospective for further exploration. Around 690 soil samples from five meter depth were collected from 89 sq. km. survey area in a grid pattern of 500 m x 250 m.

These soil samples were subjected to chemical treatment under vacuum in specially designed desorber assembly to desorb gaseous hydrocarbons. Desorbed gases were analysed for their light hydrocarboncontent by gas chromatograph using FID. Statistical data processing was carried out to analyse the data population for distribution pattern, to determine various ratios for genetic correlation, to find the values for identifying the anomalous data set for delineating the area associated with anomalous population. Contouring was carried out using surface mapping software. Hydrocarbon composition trend, cross plots and various ratios recognize gas seepages as thermogenic, of catagenetic origin, genetically related and least influenced by secondary alteration during their upward migration and adsorption on soil. The assessment of hydrocarbon anomalies after superimposing on time structure map of Kalol top indicate that north-eastern part of the survey area is most prospective. Itfallsbetween four N-S trending faults. Area in north-west and southern-central also seems to be promising for further exploration.

Introduction

Natural macro seepage of hydrocarbons from subsurface were of great historical importance as an exploration tool for locating oil and gas reservoirs that have led to the discovery of many important oil and gas producing areas of the world. Surface geochemical exploration is a petroleum prospecting tool based on premise that subsurface hydrocarbon pool is an unstable mass not in equilibrium with its surroundings and that hydrocarbon migrate upwards and get adsorbed on near surface sediments/soil, which can be used to evaluate exploration potential of an area (Horvitz, 1984). It can greatly reduce the exploration risk of the exploration area and supplements more expensive 3-D geophysical survey.

Light hydrocarbons in soil are the most important indicator in geochemical exploration of hydrocarbons. The successful application of geochemical prospecting through near surface soil samples is based on the fact that no significant amount of saturated hydrocarbons, especially ethane through pentane is present in near surface soils from sources other than petroleum.

This paper presents the finding of a geochemical survey carried out in southern part of Gamij area of Ahmedabad block of Cambay basin. The well density in the area selected for geochemical survey is very low. Faults and fractures are not identifiable in western-southern area. Surface geochemical prospecting by micro seep survey might help in identifying areas for further exploration.

General Geologyof the Area

Gamij field falls in Ahmedabad and Cambay- Tarapurtectonic block and is located on the rising flank of the Eastern margin (Fig.1).Gamij field has established commercial hydrocarbon production from Kalol, Chhatral and Olpad pays. The longitudinal Eastern basin margin faults have influenced and controlled the sedimentation pattern as manifested by sand alignments and drastic thickness variations of various units across this fault.

Paleogene sediments in the Eastern basin margin have been divided into four sequences, namely, sequence-I (Paleocene), sequence-II (Early Eocene). Sequence-III (Mid Eocene) and sequence-IV (Late Eocene- Oligocene) based on chronostratigraphic correlation. Sequence-III of Mid-Eocene comprises Sertha and Wavelmembers of Kalol Formation. The sequence becomes very compressed in margin areas and is mostly undifferentiated in eastern part of Gamij area. Sequence –II of Early Eocene mostly consists of Cambay Shale Formation. The sequence is dominantly argillaceous having sand/ silt development of Chhatral unit in upper part. Chhatral unit is mostly developed in the northern sector in Gamij- Mahuda area and is hydrocarbon bearing.Hydrocarbons in multiple pays are sourced from Cambay shale. Older Cambay Shale shows good organic matter richness in the Eastern margin area of Ahmedabad.

Methodology

The field survey was designed on a regular grid of 500 m X 250 m in an area of 89 Sq. Km. and around 690 soil samples were collected from hand augured dry holes of 5 metre depth through core catcher.

The samples were processed for homogeneity. The fine grained portions (<150 µ) were subjected to chemical treatment under vacuum in specially designed glass desorber assembly to release the adsorbed hydrocarbon gases.The desorbed gases were analysed for the presence of adsorbed light hydrocarbons (methane through pentane) by highly sophisticated gas chromatograph using flame ionization detector and the data thus obtained was processed.

Statistical data processing was carried out to analyse the data population for distribution pattern, to determine various ratios for genetic correlations, to find the values for identifying the anomalous data set for delineating the area associated with anomalous population. The hydrocarbon anomalies were superimposed on structure and fault maps to discern their relationship with subsurface geological structures.

Results and Discussion

A. Origin, nature and genetic correlation of seeped gases

The presence of hydrocarbons up to pentane in most of the soil samples, in hydrocarbon composition trend of C1>C2>C3>C4>C5, indicates that micro seepage of hydrocarbons is from subsurface,arethermogenic (Dickinson and Matthews, 1993) andare of petroliferous origin.

Genetically, near surface hydrocarbons gases can be bacterial, early diagenetic, thermogenic, or of mixed origin. They may be generated in shallow sediments and soil, or at the greater depth associated with oil and gas generation. Additionally, soil moisture, soil mineralogy and microbiological activities can variously affect different soil gas survey methods. Number of researchers (Jones &Drozd, 1983, Bernard et al., 1977, Bernard,1978,Nikanov, 1961, Yasenev, 1986 and Schumacher, 2003) published some empirical soil gas ratios based on thousands of measurements from several oil fields. These ratios are developed as a way to predict the type of petroleum present at depth (wet gas, dry gas or oil) and also to predict about the nature of hydrocarbon in the sub surface pools from where they seep to surface. These ratios also act as a filter to eliminate false indications of anomalous conditions.The status of various ratios in the survey area is shown in Table-1.

The table show that all the aforesaid ratio values of Southern Gamij areaare characteristics of the subsurface pool containing oil. It clearly indicates that the soil gases are genuine micro seepages from subsurface hydrocarbon pools. The C_1/ (C_2+C_3) ratio for the samples have value less than 10 suggesting that the micro seep gases are of catagenetic origin and associated with oil (Bernard, 1978).

The cross plots C1 vs. C2 (Fig. 2) and C2 vs. C3 (Fig. 3) indicate that most of the samples contains adsorbed gas associated with liquid hydrocarbon as they are falling in oil/ oil & gas zone.

Cross plot C_1/C_2 vs. $C_1/(C_2+C_3)$ (Fig. 4) shows approximately linear relationship suggesting that the hydrocarbon constituents in micro seeps are genetically related and least influenced by secondary alteration during upward migration from the subsurface to the surface and their subsequent adsorption on the soil.It is also recognized that the gas source is predominantly thermogenic, not biogenic methane (Dickinson and Matthews, 1993).

The microseep survey has indicated the presence of surface hydrocarbon charge, not influenced by secondary effects during migration and adsorption on sub surface soil.

B. **Delineation of Surface Hydrocarbon Anomalies.**

Since the surface manifestations of the hydrocarbons are directly related to the sub-surface accumulation, the magnitude of the geochemical anomalies determines the relative strengths or significance of the anomalies in the area (Dickinson and Matthews, 1993).

In the present study iso-concentration contour maps of hydrocarbons (C_1 to C_5) have been generated with starting contour at $M+\sigma$ and contour interval ofone standard deviation (1σ). Propane anomalies with strength of $M+4\sigma$ and above have been considered as anomalous in nature. In South Gamij area twenty two anomalies with strengths ranging from $M+4\sigma$ to $M+38\sigma$ have been delineated for propane (Fig. 5). For better comprehension during discussions, these anomalies are classified as A, B and C categories, depending on their strengths. Of these, one anomaly is categorised as ‘A’ (strong), three anomalies as ‘B’ (moderate) and eighteen as ‘C’ category (modest) anomalies. The propane anomaly map has been superimposed on time structure mapof the area(Fig. 5).

The assessment of hydrocarbon anomalies with respect to their distribution in the survey area indicates that north-eastern portion of the survey areais covered with cluster of propane anomalies of various strengths. This north-eastern area seems to be most prospective from surface geochemical point of view. This is the area with maximum density of hydrocarbon anomalies in the survey area.There are three major N–S and one E-W trending faults, viz., F4, F5, F6 and F7 passing through eastern portion of the survey area.

The north-west part of the survey area lying west of fault F2 has cluster of a moderate and twomodest anomalies and is also prospective for exploration.

The central portion of the survey area, westof N-S trending fault F4 has cluster of one moderate and three weak propane anomalies and is also prospective.

Conclusions

The survey has shown the presence of high concentration of hydrocarbons (C_1 to C_5) in the surface soil at several locales. These hydrocarbons are catagenetic in origin, petroliferous in nature and indicate their association with oil.

North-east portion of the survey area is marked by intense hydrocarbon anomalies and most prospective for hydrocarbon exploration. Areas in north-west corner and in southern-central partshows moderate anomalies and arealso prospective for hydrocarbon exploration.

The micro seep survey has thus identified thrust areas with positive surface hydrocarbon micro seep anomalies to prioritise exploration in South Gamij area.

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References

1. B. B. Bernard, J. M. Brooks and W. M. Sackett, “Natural gas seepage in the Gulf of Mexico”, Earth Planet Sci. Letters, 32, 48-51, 1977.

2. B. B. Bernard, “Light hydrocarbons in marine sediments”, Ph.D. Dissertation, Texas A and M University, USA,144, 1978.

3. R. G. Dickinson, and M. D. Mathews,“Regional Microseep Survey of Part of the Productive Wyoming Utah Belt”, AAPG, 77, 1710-1722, 1993.

4. Leo Horvitz, “Near surface evidence of hydrocarbon movement from depth”, Robert, W.H.III and Cordell, R. J. (eds.), Problems of Petroleum migration studies in Geology, AAPG, 10, 241-269, 1980.

5. V. T.Jones and R. J. Drozd, “Predictions of Oil or Gas Potential by Near Surface Geochemistry”, AAPG, 67, 6, 932-952, 1983.

6. V. F. Nikonov, “Heavy hydrocarbons in gases of oil and gas pools and their relationship”, Petrol. Geol., 5, 437, 1961.

7. D. Schumacher, “Geochemical exploration for oil and gas Strategies for success”, An Exploration short course at International Institute (NGRI), Hyderabad, India. Symposium on Geochemical Prospecting, 2003.

8. B. P. Yasnev, “New data on direct geochemical methods on prospecting for oil and gas”,Petroleum Geology, 3, 1986.

Table-1: Gas Ratios and Nature of Sub- Surface Pool

Composition	**C_1/C_2+C_3**	**(C_3/C_1)*1000**	**$(C_1/\Sigma C_1\text{-}C_4)$*100**	**C_2/C_3**
Dry Gas	>100	2 - 20	95 - 100	4 - 6
Gas Condensate/ Oil & Gas	10 - 100	20 - 60	75 - 95	2.5 - 4
Oil	≤10	60 - 500	55 - 75	1 - 2.5
Ratio in the Southern Gamij Area	***3.83***	***103.09***	***75.44***	***1.89***

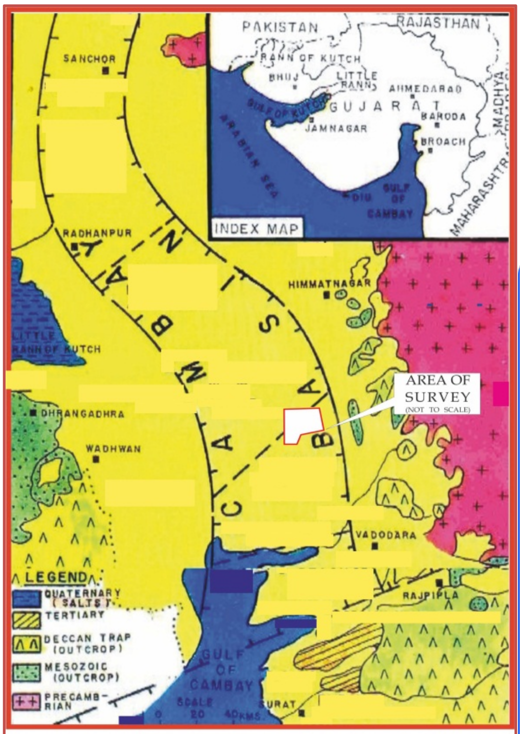

Fig.1:Location Map of Study Area

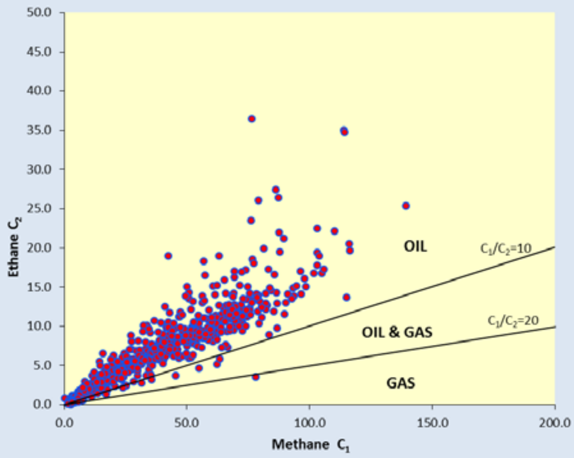

Fig 2: Cross Plot of C_1 Vs C_2

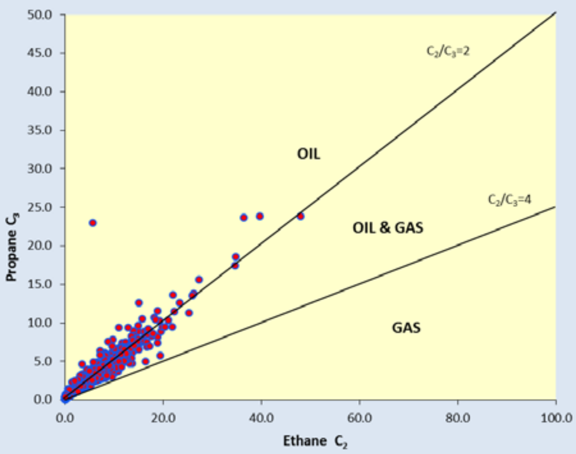

Fig 3: Cross Plot of C_2 Vs C_3

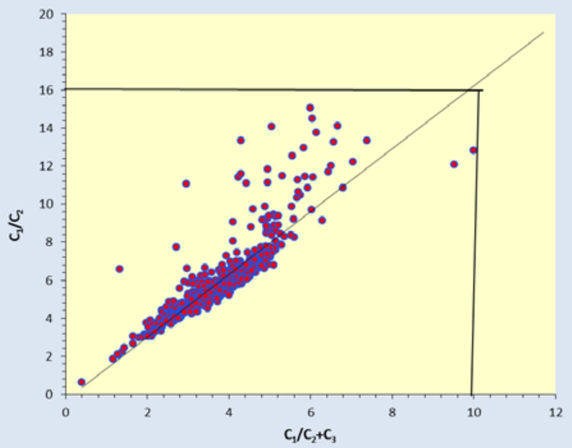

Fig 4: Cross Plot of C_1/C_2+C_3 Vs C_1/C_2

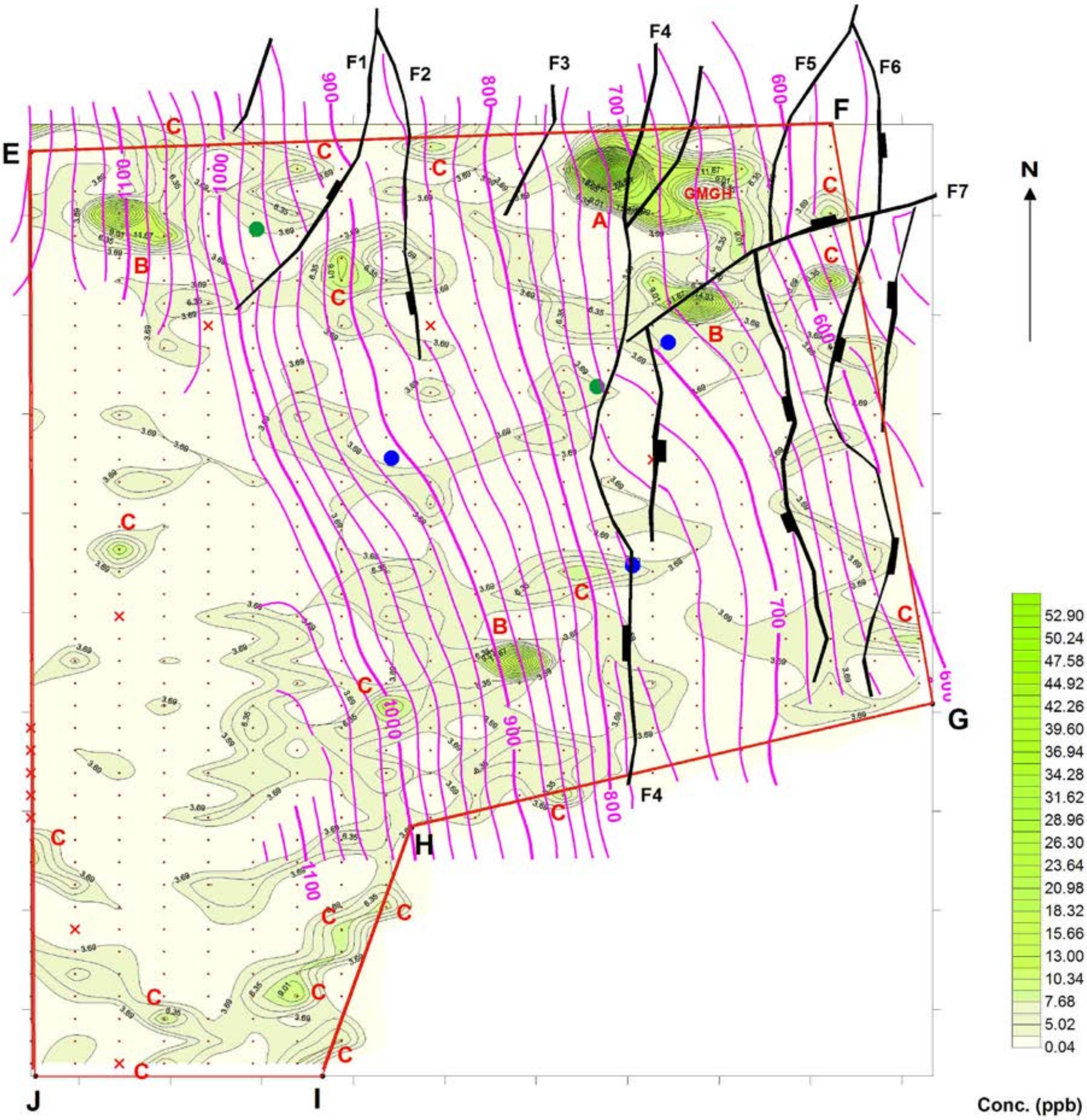

Fig. 5: Propane Anomaly Map overlain with Time Structure Map

Concentration (ppb):

Starting Contour : 3.69 (Mean+ 1 S.D.)
Max : 53.95
Mean: 2.36
Contour Interval : 1.33 (1 S.D.)

Legends:

- **- Samples Collected**
- **- Samples not Collected**
- **- Villages**
- **- Dry/Abandoned Wells**
- **- Oil Wells**

0m 2500m 5000m

1cm. = 500 meters