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Evaluation of Hydrocarbon Prospectivityby Non-seismicMicrobial Anomalies Method in Khubal Area of Tripura, India

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Summary

Geomicrobial hydrocarbon prospecting methods which involves quantification and distribution of hydrocarbon utilizing bacteria (HUB) in surface sediment has become a cost effective and new methods of the modern petroleum exploration that enhances exploration success and reduces finding costs. It offers more effective way of hydrocarbon finding and improving discovery rates in integration with other geophysical and geological exploration techniques. Evaluation of hydrocarbon prospectivity has been carried out in this present work for prioritizing leads and prospects on the basis of microbial anomalies in Khubal area of Tripura and understanding the genesis of the anomaly and its relationship with oil and gas accumulations by non- seismic microbial anomalies method.

A total of 20 no.s microbial anomalies, potential hydrocarbon migration indicator have been delineated in study area which may be considered as potential hydrocarbon migration pathways /seepage. Microbial anomalies found in study area have been integrated with geological structure map in time which discloses the presence of microbial anomaly in the vicinity of faults. Possible hydrocarbon sources could be in the distant northern part of study area and hydrocarbon migration /seepage occurs primarily through various faults and cross faults. Microbial anomalies are found to be concentrated on both side of cross fault-2 (CF2) and mostly terminated within cross fault-6 (CF6) which indicates possibly maximum hydrocarbon migrations around both side of cross fault-2 (CF2). Only minor anomalies/ migrations could have been observed in the south east part of study area crossing CF2. However no anomalies have been observed in the south and south west part of study area crossing CF2. Therefore, areas on either side of CF2 seem to have good hydrocarbon prospectivity but south and south west part of study area are seem to be poor hydrocarbon prospectivity.

Occurrence of delineated microbial anomaly in the vicinity of faults show authentication of this non seismic technique with Geophysical and geological exploration techniques and hydrocarbon migration in the study area seem to be driven by folding and faulting.

***Keywords**: Geomicrobial hydrocarbon prospecting, Non seismic method*

Introduction

In petroleum exploration, various useful techniques involving geology, geophysics, geochemistry and geomicrobial studies are employed to get various indirect information regarding presence/absence of hydrocarbons in sub-surface. Geo-microbial hydrocarbon prospecting is an indirect, economical and reliable method for evaluating exploration leads and prospects based on the principles that lighter hydrocarbons existing below the sub- surface, escape to the earth's surface due to micro/macro seepages from the reservoirs and create favorable conditions for microorganisms to grow and develop at the surface. It helps us to define individual prospects and also evaluate remote exploration areas based on direct and positive relation between hydrocarbon concentration in soil and spread of hydrocarbon utilizing bacteria (HUB) which feed on light hydrocarbons in surface soil samples can be measurable and reproducible. It offers more effective way of hydrocarbon finding and improving discovery rates in integration with other exploration techniques. Evaluation of hydrocarbon prospectivity has been carried out in this present work for prioritizing leads and prospects on the basis of microbial

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anomalies in Khubal area of east Tripura and understanding the genesis of the anomaly and its relationship with oil and gas accumulations by non-seismic microbial anomalies method.

Sample and method

A total of 763 surface soil samples were collected in association with seismic data acquisition by GP-09 & GP-90 seismic field parties. Collection of soil samples was done by specially dug holes at approx. 1.5 m below the surface. Soil samples were collected along the horizontal and vertical lines. The distance between two adjacent sampling points along the line is approx. 500 metres. Samples were aseptically packed, sealed in sterile sample bottles and stored below 4oC to control microbial growth for analysis.Structure contour map in time of study area has been provided by Assam Arakan fold block group of A&AA Basin, Jorhat.

HUB count was determined taking 1 gm of dispersed soil sample in 100 ml of sterile water to get 1% solution and serially diluted to get lower concentrations. Mineral salt medium (MSM) was prepared as per the composition given in Table 1. The pH of MSM was adjusted to 7± 0.1 and

Sl.No.	Ingredients	Quantity
1.	Sodium Nitrate, $NaNO_3$	2.00 gm
2.	·7H O	0.20 gm
3.	Potassium Chloride, KCl	0.04 gm
4.	Calcium Chloride, $CaCl_2$	0.015 gm
5.	Disodium Hydrogen Phosphate, Na_2HPO_4	0.21 gm
6.	Sodium Dihydrogen Orthophosphate, NaH_2PO_4	0.09 gm
7.	Ferrous Sulphate, $FeSO_4$ 2	0.10 gm
8.	Copper Sulphate, $CuSO_4 \cdot 5H_2O$	05 µg
9.	Boric Acid, H_3BO_3	10 µg
10.	Manganese Sulphate, $MnSO_4 \cdot 5H_2O$	10 µg
11.	·7H O	70 µg
12.	Molybdenum Oxide, MoO_3	10 µg
13.	Deionised Water	1000 ml
14.	Agar	2 %
		pH = 7.0 ±0.1

Table 1: Composition of mineral salt medium

sterilized at 15 psi and 121°C for 15-20 minutes. Then the diluted sample was plated on petri-plates in agar mineral salt medium. LPG gas (propane and butane), free from mercaptan was introduced along with zero air in the ratio of 1:1 on airtight desiccators in which the petri plates were placed, and kept in incubator at 37±1°C. Since, only propane and butane were the carbon source, bacteria capable of oxidizing propane and butane would develop in the petri plates after two weeks of incubation. HUB growth was determined manually by plate count method and quantified using a colony counter.

Basin evolution, tectonics and stratigraphy

The study area was located on the eastern passive margin of the Indian plate.The movement and interaction of the Indian, Antarctica, and Australian plates, and the Eurasian and Burma plate through time are responsible for the patterns of basin formation, sedimentation, and structure that characterize the petroleum system (Curiale et al., 2002). The evolution of this amalgamated basin begins from an arc-trench type subduction and subsequent continental accretion, to a convergent plate margin scenario through plate convergence, over thrusting and wrench fault tectonics. The northward movement of Western Burma culminated in the uplift of the Cachar-Tripura Foldbelt during the Late Pliocene to Pleistocene resulting in thrusting, folding, reversal of regional deep and development of N-S oriented (1.8-5 Ma) anticlinal structures(Deshpande et al., 1993) The study area contains north-south elongate transgressional en echelon anticlines separated by wide flat synclines (Figure-1). The steeper flanks of the anticlines commonly form monocline steps and these are often dislocated and upthrown against the gently deeping flanks by longitudinal listric reversal faults and number of cross faults trending NE-SW and ENE-WSW. The intensity of folding and faulting decreases from east to west. Surma Basin and Bengal Basin, Hailhakalula lineament, Assam Shelf/ Assam Foreland, Shillong Plateau / Mikir Hills, Dauki Fault, Tripura-CacharFoldbelt, Kaladan fault Zone and Indo-Burma Ranges are the main tectonic elements associated with the study area (Figure-1).

The generalized stratigraphy of the block shows the age of formation starting from Early Miocene to Pliocene/Recent is given in Table-2:

Age	Formation	Thickness (m)	Brief Lithology
Early Pliocene	Tipam	800	Mainly sandstone with shale and siltstone interlamination
Late Miocene	Bokabil	900	Dominantly shale / claystone with few sandstone beds
Middle Miocene	Up. Bhuban	600	Mainly sandstone with alteration of thick shale with siltstone
Early Miocene	Mid. Bhuban	700	Dominantly shaly sequence with siltstone and sandstone intercalations.
	Lr. Bhuban	70+	Mainly sandstone towards top with shale and siltstone interlamination with few thick shale sequence.

Table 2: Generalized stratigraphy of study area

Results and Discussion

HUB counts represent the indication of presence of hydrocarbons below the earth's surface. If there were to be no hydrocarbons source, such as micro seepage present below the earth, the population of microbes would not have been significant. The high population of HUB on the surface is correlated with subsurface accumulation of hydrocarbons. It may be inferred that the presence of gaseous hydrocarbon in soils at depths greater than 1.5 meter was due to their migration from the buried hydrocarbon pool. The presence of fault/fissures may cause lateral displacement of the gas by the preferential migration of gas along with fault zone at the surface causing bacteria anomaly (Dostalek and Spurny 1962). HUB counts anomalies may manifest in different ways i.e. (a) focal, where the indicator microorganisms are found at separate, disconnected points (b) Continuous, where indicator organisms within the limits of definite regions are found at all examined points with considerable intensity, (c) Peripheral which may be due to fracture/fissures in the rocks, motion of ground waters and geomorphological pecularities in the structure of the earth surface (A. K. Jain et al). Microbial anomalies in the study area seem to be peripheral type.

The average concentration of hydrocarbon between the limits of anomaly should be at least 1.5 times that of the background. Ratios of 1.6 to 2.0 were normally encountered and ratios of 2.0 to 10.0 were rare according to Kartsev et al. (1959). HUB count of $325x10^3$cfu/g is taken as basis for counting anomalies forstudy area. Nevertheless, the threshold value should not be taken in isolation, but should be seen in conjunction with the surrounding values.

Contour of HUB counts data of study area is generated and shown in Figure-2. It exposesa total of 20 no.s microbial anomalies, a potential hydrocarbon migration indicator. Anomalies found in study area has been integrated with geological structure map (Figure-3) which discloses possible hydrocarbon sources could be in the distant north west part of study area and hydrocarbon migration /seepage occurs first through cross fault 4 (CF4) towards north east of study (north and north-west of location A), then through cross fault 3 (CF3) and Fault 6 (F6, on either direction) towards Location B and C respectively. Maximum seepages/migrations are found to be concentrated up to D and mostly terminated within cross fault (CF2). Only minor migrations/ seepages could have been observed in the south east part of study area crossing CF2 and does not seems to have reached crossfault-6 (CF6).

Conclusion

A total of 20 no.s microbial anomalies, potential hydrocarbon migration indicator have been delineated in study area which may be considered as potential hydrocarbon migration pathways /seepage. Microbial anomalies in the study area seem to be peripheral type.

Microbial anomalies found in study area have been integrated with geological structure map in time which discloses the presence of microbial anomaly in the vicinity of faults. Possible hydrocarbon sources could be in the distant northern part of study area and hydrocarbon migration /seepage occurs primarily through various faults and cross faults. Microbial anomalies are found to be concentrated on both side of cross fault-2 (CF2) and mostly terminated within cross fault-6 (CF6) which indicates possibly maximum hydrocarbon migrations around both side of cross fault-2 (CF2). Only minor anomalies/ migrations could have been observed in the south east part of study area crossing CF2. However no anomalies have been observed in the south and south west part of study area crossing CF2. Therefore, areas on either side of CF2 seem to have good hydrocarbon prospectivity but south and south west part of study area are seem to be poor hydrocarbon prospectivity.

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Acknowledgements

Authors are deeply grateful to Shri S. K. Jain, GM-Basin Manager, ShriSoumitra Gupta, DGM (Geol) and his team for extending support to carry out this study and for providing relevant data/map of study area. Authors acknowledge their gratitude to Shri, C.L.Baloni, GM (GP)-HGSand Field party chiefs of GP-9 and GP-90 along with their team for guidance, suggestions and assistance for sample collection. Authors are indebted to Shri Naren Das, TA-III (Chem) and Shri Pranjol Gogoi, JTA (Chemistry) for collection of samples & analysis and Ms. Bonti Saikia Neog, JTA (Chem) for her support in analytical work.

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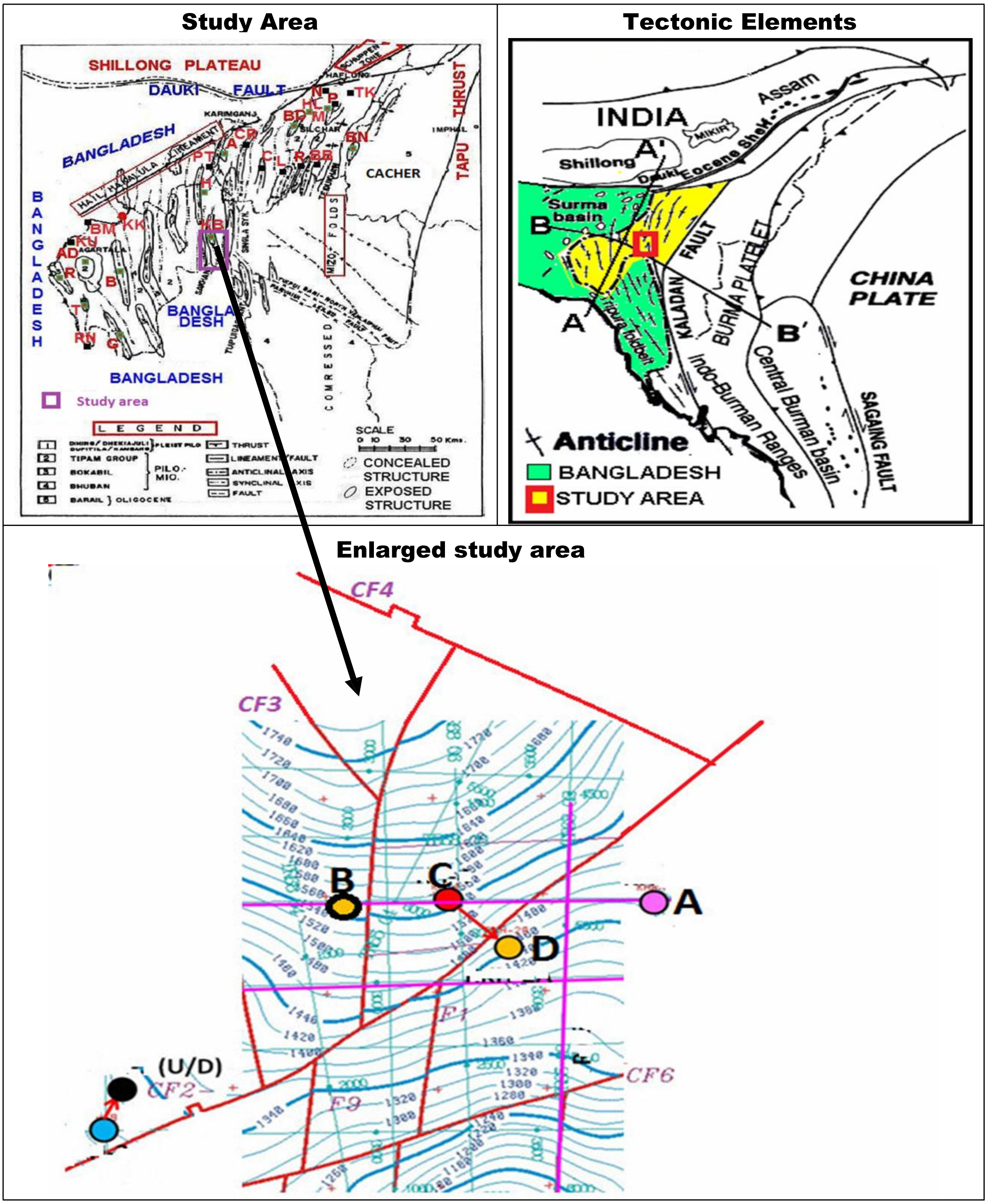

Figure 1: Location and tectonics map of study area

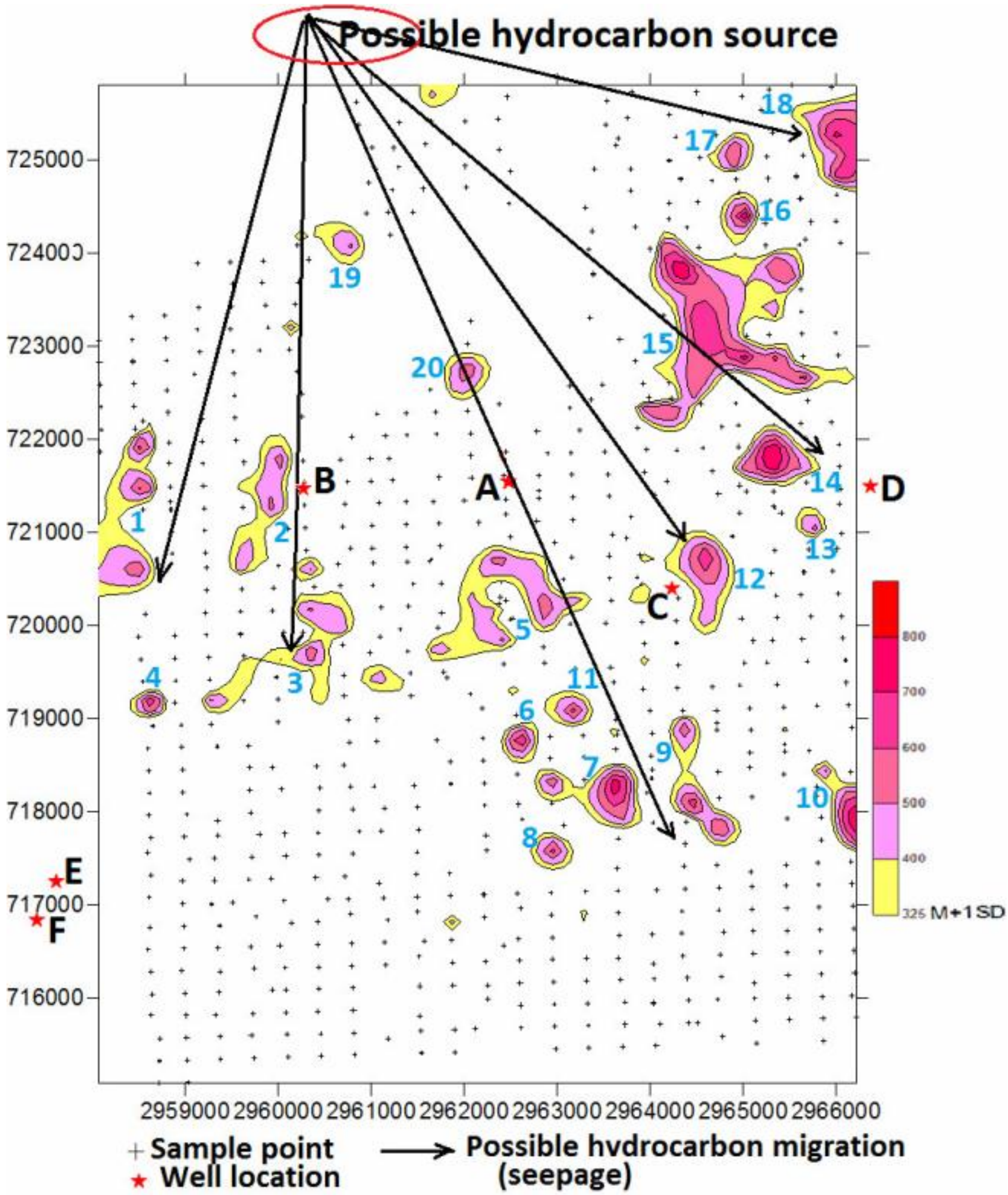

Figure 2: Delineated Microbial anomalies map of study area

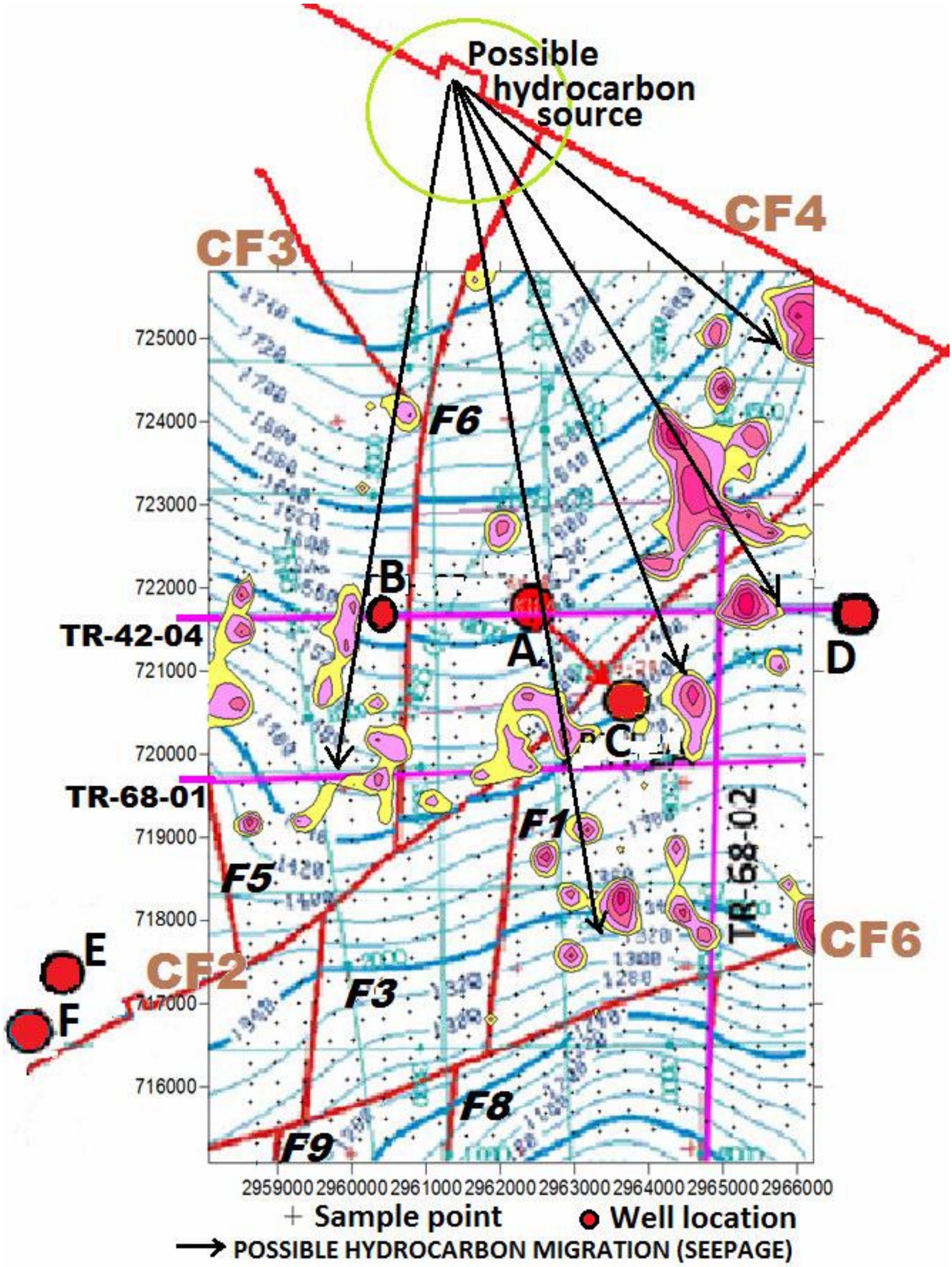

Figure 3:Microbial anomalies along with geological structure map (time) of study area