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Integrated Surface Geochemical and 3D Seismic Studies to understand the Hydrocarbon Seepage Pattern

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Summary

Surface geochemical prospecting is one such unconventional technique that has emerged as one of the vital components of any exploratory program. It is based on the seepage of hydrocarbons from the subsurface reservoirs to the shallow surface environment which results in surface hydrocarbon anomalies. Surface geochemical prospecting is a search for hydrocarbon seepage. Adsorbed soil gas and Geo-microbial studies are two types of geochemical techniques which are used to identify hydrocarbon microseepage from the subsurface petroleum reservoirs. The proposed study aims at integrated approach using geo-microbial, adsorbed soil gas and 3D seismic studies to understand the mechanism of hydrocarbon seepage and to evaluate the hydrocarbon potential in a block falling in Onshore KG Basin. An attempt has been made to correlate the geochemical anomalies with microbial anomalies reveals that, Adsorbed propane indicate that the anomalies follow the natural model depicting 'Halo' pattern. Integrated anomaly plots between adsorbed light hydrocarbons and bacterial anomalies, demonstrate that light hydrocarbon distribution showed low signal resulting in a halo anomaly and the bacterial activity to hydrocarbon concentration exhibited an apical anomaly. Integration of the geo-microbial and adsorbed soil gas data with 3D seismic data shows that the geochemical anomalies were observed in the vicinity of the major fault and these may be due to the feeble gases which have generated from HG – HR shale section and have migrated along this fault and deposited in the shallow regions. The studies have showed that high C_1 anomalies were observed at the surface above the faulted region, due to the seepage of light hydrocarbon gases along the vicinity of the major fault to the surface. However, high amplitude - low frequency events along with high sweetness anomalies are seen near shallow depths, which may be indicative of shallow gas pockets in the study area. Based on the integration it is interpreted that the geochemical anomalies observed, are may be due to some Marshy shallow gas pockets, as delineated in the seismic or may be due to seepage through the main fault.

Keywords: *Geochemical, 3D Seismic, microbial prospecting, micro-seepage, hydrocarbon exploration.*

Introduction

Cost-effective exploration, mainly depends on optimization and integration of appropriate and efficient exploratory tools. In order to cut down the drilling cost proper integration with geological and geophysical data is necessary. This way can contribute to the successful high grading of exploratory prospects and helps in risk reduction of dry holes. Surface geochemical prospecting method is based on the seepage of hydrocarbons from the subsurface reservoirs to the shallow surface environment which results in surface hydrocarbon anomalies (Price, 1986; Tedesco, 1995; Klusman and Saeed, 1996). The tectonic features such as faults and fractures provide a pathways for the hydrocarbon migration, causing geochemical anomalies at the surface. Micro seeps are invisible and can be recognized by the presence of anomalous concentrations of light hydrocarbons (C1 to C4) in the near surface soils/sediments along with other surface manifestations of hydrocarbon seepage which can be in the form of microbial and trace element anomalies, mineralogical changes, altered electrical, magnetic and seismic properties (Pareja, 1994; Tucker and Hitzman, 1994). Microbial prospecting of hydrocarbons is based on the detection of anomalous population of hydrocarbon oxidizing bacteria in the surface soils, which indicate the presence of subsurface oil and gas accumulations. The technique is based on seepage of light hydrocarbon gases such as C_1 - C_4 from the oil and gas pools to the shallow surface that provide the suitable conditions for the development of highly specialized bacterial populations. These bacteria utilize hydrocarbon gases as their only

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food source and are found enriched in the near surface soils above the hydrocarbon bearing structures. Adsorbed soil gas and Geo-microbial studies are two types of geochemical techniques which are used in the study to identify hydrocarbon microseepage from the subsurface petroleum reservoirs. The principal objective of a geochemical exploration survey is to establish the presence and distribution of hydrocarbons in the area and, more importantly, to determine the probable hydrocarbon charge to specific exploration leads and prospects. The proposed study aims at integrated approach using Geochemical studies such as adsorbed soil gas and microbial with 3D Seismic data to understand the mechanism of hydrocarbon seepage and to evaluate the hydrocarbon potential of the study area.

Methodology

The adsorbed soil gas analysis was carried out using GC-FID to analyzed light hydrocarbons (Methane-C1, Ethane-C2, Propane-C3 and Butane-iC4, nC4). The calibration of GC was done by using external standards and quantitative estimation of light gaseous hydrocarbon constituents in each sample was done on the basis of peak area measurement and the correction for moisture content was applied to the data obtained. The presence of hydrocarbon oxidizing bacteria was done using Standard Plate Count (SPC) method, using Mineral Salts Medium followed by 10 days of incubation at 37ºC. The Seismic data interpretation and attribute analysis was done using OpendTect V.4.4 software. Integration of geochemical and seismic attributes was done using Arc GIS and OpendeTect 4.4 software's.

Results and Discussion

The adsorbed soil propane gas concentration map is shown in Figure 1. The concentration distribution map of ∑C2+ shows that the high concentrations are located near southern, north-west, south-east part of the study area. Microbial blooms of high concentrations of propane oxidizing bacteria were observed in southern, central, north-east, northern part of the study area. Integrated anomaly plots between adsorbed light hydrocarbons and bacterial anomalies, demonstrate that light hydrocarbon distribution showed low signal resulting in a halo anomaly and the bacterial activity to hydrocarbon concentration exhibited an apical anomaly. The figure 1 denotes the regions where Propane oxidizing bacteria anomaly is high and correspondingly the ΣC_2+ anomalies are scanty or very little in that particular region showed as encircled region, the encircled region in the NE and the SE part show higher microbial anomaly but lower adsorbed soil gas anomaly. This is because of consumption of these hydrocarbons by bacteria, thus reducing the hydrocarbon concentrations in soil.

Integrated approach has been made to give principal evidence on the occurrence of hydrocarbon anomalies in large areas where subsequent seismic investigations could be concentrated on favorable areas in those regions where structure data of the sub-surface could be found. Figure 2 shows RMS amplitude distribution on shallow surface H1 indicating higher amplitudes in the NE and SE of the block which are co-relatable with the geochemical anomalies.

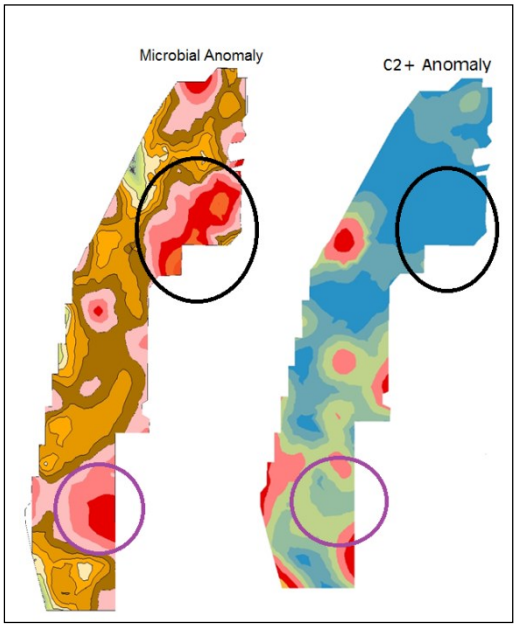

Figure 1: Microbial and Adsorbed higher hydrocarbons (C2+) anomaly maps illustrate halo and apical anomalies.

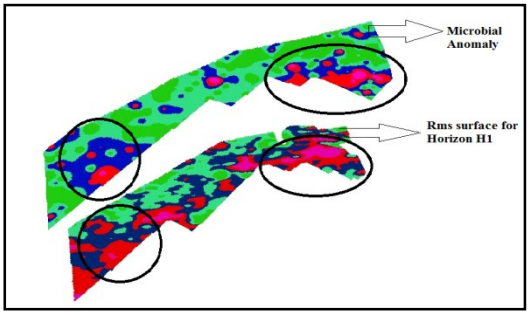

Figure 2: Represents stacked maps of horizon H1 and microbial anomaly

The time structure contour map was generated for better understanding of the trends of bedding layers and is shown below in figure 3. It is observed that the contour lines run parallel to each other in the entire study area describing the trend of the beds showing no presence of any structural entrapment. Two major faults identified in the area, also does not create any structural feature for oil and gas to be entrapped. The contours only depict the slopping direction of the entire area which is from NNW to SSE.

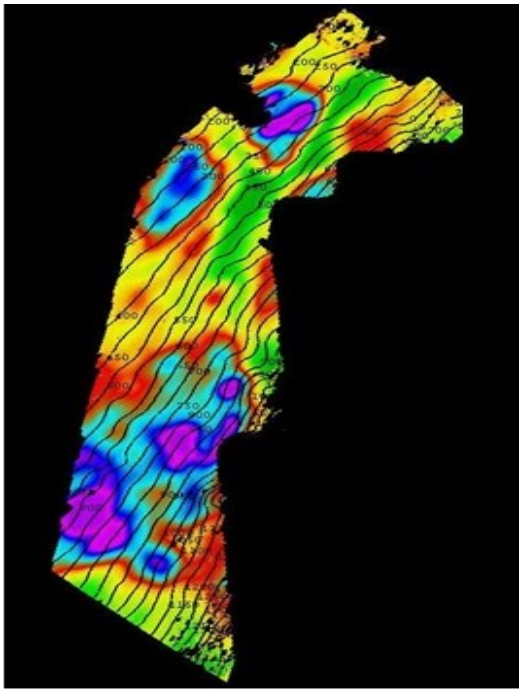

Figure 3: Time Structural contour map of the block.

Sweetness amplitude map (Figure 4) was generated along Shallow Surface (H1) show High sweetness is due to the presence of high amplitude-low frequency events.

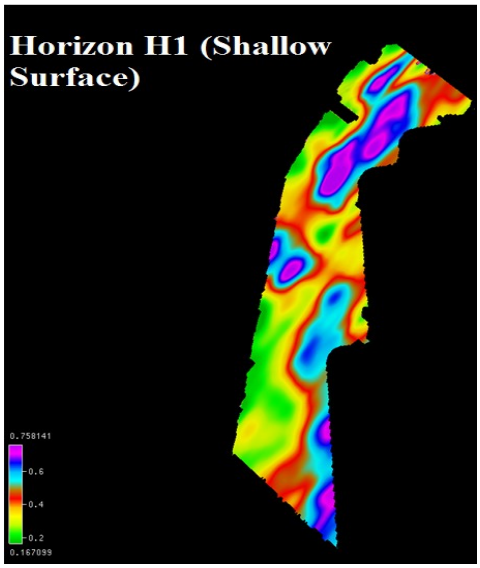

Figure 4: Sweetness amplitude map along Shallow Surface (H1)

A random seismic section from SE to NW passing through the deepest drilled well indicating the deep seated faults which are propagating to the near surface. This seismic section is highly faulted and integrated with C_1 anomalies (Figure 5), which indicates high amplitude, low frequency events at near shallow depths. The Integrated study has showed that high C_1 anomalies at the surface above the faulted region and observed that light hydrocarbon gases seeped along the vicinity of the major fault to the surface.

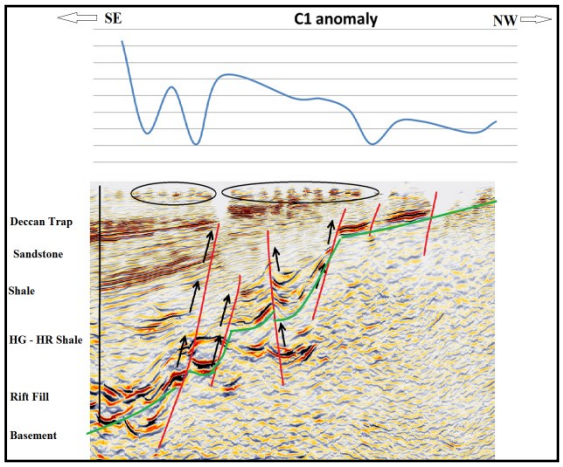

Figure 5: Seismic section integrated with C_1 anomalies. Region is highly faulted. Encircled part near shallow depths indicates high amplitude, low frequency events.

Conclusion

Detailed Seismic studies indicate that there are no structural prospects in the study area. However good thickness of shale is observed in the eastern part of the study area and thickness narrows down towards western side. High amplitude and low frequency events are observed near the shallow depth, which are seen on RMS and Sweetness attribute maps and as well correlated with surface geochemical (adsorbed soil gas and microbial) anomalies. No entrapment structure is available in the study area. A major deep seated fault oriented in NE to SW may be a conduit for seepage of hydrocarbons to the shallow depths, resulting in high amplitude low frequency events near surface, which are well supported by the geochemical anomalies. High amplitude - low frequency events along with high sweetness anomalies are seen near shallow depths, which may be indicative of shallow gas pockets in the study area. Based on the integration it is interpreted that the geochemical anomalies observed, are may be due to some Marshy shallow gas pockets, as delineated in the seismic or may be due to seepage through the main fault.

In summing up, it can be concluded that integration of geo-microbial and adsorbed soil gas anomalies along with 3D seismic data, one can narrow down the best possible location for hydrocarbon exploration. Such techniques are useful in virgin areas to reduce the pre-production investment in petroleum industry.

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