P 165

Integrated light Gaseous Hydrocarbons and Bacterial Anomalies for Identification of Hydrocarbon Seepage in Pranahita-Godavari Basin, Andhra Pradesh

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Summary

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. The sub-soil samples from Pranhita Godavari Basin were analyzed for adsorbed light gaseous hydrocarbons using GC-C IRMS (Gas Chromatograph Combustion Isotope Ratio Mass Spectrometer. The adsorbed light gaseous hydrocarbons ranged as methane C_1 (1 to 138 ppb), $\sum C2+$ (1 to 50 ppb) was measured in the soil samples. The microbial prospecting studies showed the presence of high hydrocarbon oxidizing bacteria (4.2 x 10^5 cfu/gm) in soil samples. Study of soil samples suggests the area has good potential for hydrocarbon and the carbon isotopic composition of $\delta^{13}C_1$ of the samples ranges between – 36.6 ‰ to -22.7‰ (V-PDB) values indicate thermogenic origin, which presents convincing evidence that the adsorbed soil gases collected from these sediments are of thermogenic origin. Integrated adsorbed soil gas, microbial and carbon isotope studies have shown good correlation.

Keywords: *Geochemical prospecting, hydrocarbon oxidizing bacteria, hydrocarbon micro-seepage.*

Introduction

Surface geochemical prospecting is a search for hydrocarbon seepage. The light gaseous hydrocarbons, migrate to the surface from the subsurface through microseepage and get adsorbed in the near surface soil matrix, which on acid extraction and further quantification gives an inference on the potential of the area. The tectonic features such as faults and folds provide a pathway for the hydrocarbon migration showing hydrocarbon mass at the surface. Micro seeps are invisible and can be recognized by the presence of anomalous concentrations of light hydrocarbons (C_1 to C_4) 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. The carbon isotopic studies of the desorbed hydrocarbons help in finding whether they are thermogenically or biogenically generated. These near surface anomalies provide clues on the nature and composition of sub-surface petroleum occurrences and help to demarcate the anomalous hydrocarbon zones and grade the frontier basins. (Price, 1986; Tedesco, 1995; Klusman, 1993). Microbial prospecting method is for hydrocarbon research and exploration is based on the premise that the light gaseous hydrocarbons migrate upward from subsurface petroleum accumulations by diffusion and effusion, and are utilized by a variety of microorganisms present in the sub-soil ecosystem (Rasheed et al., 2008). The methane, ethane and propane-oxidizing bacteria exclusively use these gases as carbon source for their metabolic activities and growth. These bacteria are mostly found enriched in the shallow soils/ sediments above hydrocarbon bearing structures and can differentiate between hydrocarbon prospective and non-prospective areas.

The proposed study aims to correlate adsorbed soil gas and microbial studies for hydrocarbon prospects of the study area. Adsorbed soil gas and Geo-microbial studies

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are two types of geochemical techniques which are used in the study to identify hydrocarbon microseepage from the subsurface petroleum reservoirs.

Geological Setting

Pranhita-Godavari (PG) is a large inter-cratonic Gondwana basin trending NW-SE located in the eastern part of the Peninsular India. It is filed with 3000 meter-thick sediments deposited from Late Carboniferous/Early Permian to Cretaceous. Numerous coalfields border its western margin (Fig.1). This basin is located on a paleo-suture between the Dharwar and the Bastar proto-cratons (Biswas, 2003) and is divided into three sub-basins, namely Chintalpudi, Godavari and Coastal sub-basin. Seismic studies across the Chintalpudi sub-basin delineated several basement ridges and depressions and provided a depth of Moho of 40 km. The onset of Gondwana sedimentation seems to have taken place on block-faulted Proterozoic basins that evolved due to repeated sagging along SE and NE faults. A thick, almost uninterrupted sequence of Permo-Triassic and partly Jurassic and Cretaceous sediments of mainly continental origin overlie the Proterozoic sediments. The geological formations can be divided into Lower and Upper Gondwana. The litho-stratigraphic succession of the Gondwana sediments is Talchir, Barakar, Barren Measures and Kamthi of Upper Gondwana and Maleri, Kota, Gangapur and Chikiala Formations of Lower Gondwana.

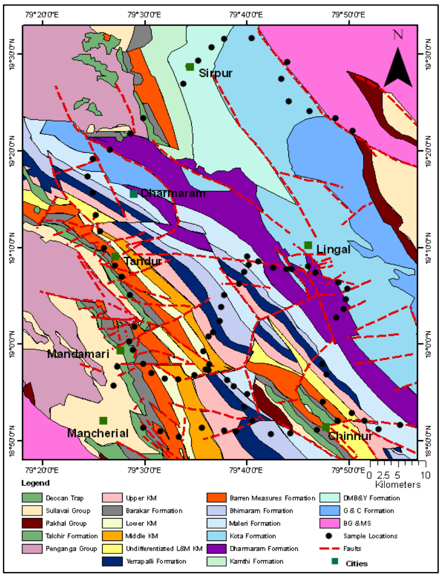

Fig.1. Geological map of Pranhita-Godavari Basin.

Methodology

Sub soil samples were collected in reconnaissance pattern from the depth of 2.5 to 3.0m by manual hammering. The samples were wrapped in aluminium foils with their GPS positions marked. The 63 micron size soil sample was treated with orthophosphoric acid under partial vacuum to desorb the soil gases. The CO2 evolved was trapped in KOH solution and the hydrocarbons released were collected through water displacement in a graduated tube fitted with rubber septa. The 0.5 ml of the gas was injected in to the Varian CP-3380 Gas chromatograph equipped with Flame ionization detector. The calibration of GC was done by external standard with known concentrations of methane, ethane, propane,. The quantitative estimation of light gaseous hydrocarbons constituents in each sample was made using peak area measurement as a basis and the correction for moisture content was applied The carbon isotopic composition of methane from the soil sample and head space gas was measured by GC-C-IRMS comprising of Agilent 6890 Gas Chromatograph (GC) coupled to a Finnigan – Delta PlusXP Isotope Ratio Mass Spectrometer via a GC combustion III interface. The carbon isotope ratio in the sample was compared with NIST RM 8560(IAEA NGS2) using ISODAT software. The precision of the isotopic measurement was ±0.5%. The isolation of light hydrocarbon oxidizing bacteria is carried out using standard plate count method. The Mineral salts medium (MSM) plates were incubated in the environment of hydrocarbons and zero air (1:1), respectively. The bacterial colonies were reported in Colony forming unit (Cfu/gm) of soil sample.

Results and Discussion

In the study hydrocarbon oxidizing bacteria ranged from 1.0 x 10^2 to 4.20 x 10^5 cfu/gm of soil sample. A statistical approach has been followed and standard deviation value is taken as a background value for the demarcation of anomalous zones. The results of hydrocarbon oxidizing bacterial population are plotted on the surveyed map. In the present study the anomalous zones for propane oxidizing bacteria were observed near Kagaz nagar, Kannepalli, Bellampalli, Manchyrial areas of the study area showing high bacterial concentrations (Fig. 2).

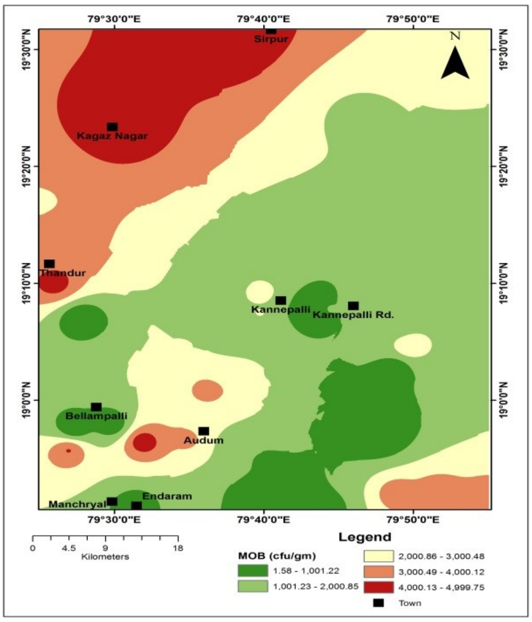

Fig. 2 Bacterial anomaly map of Pranhita Godavari Basin

The possibility of discovering oil or gas reservoirs using microbiological method is emphasized by the fact that the hydrocarbon-oxidizing bacteria range between 10^3 and 10^6 cfu/gm in soil/sediment receiving hydrocarbon micro-seepages depending on the ecological conditions (Rasheed et al. 2008; Wagner et al. 2002). The gas chromatographic studies of adsorbed soil gases shows that CH_4 is present in all the samples while $\sum C_{2+}$ is representative of 30% of the samples in the basin. The adsorbed light gaseous hydrocarbons ranged as methane C_1 (1 to 138 ppb), $\sum C_{2+}$ (1 to 50 ppb) was measured in the soil samples. The concentration distribution maps based on standard deviation and mean of the samples (adsorbed soil gases) were prepared using (Inverse distance weighted method) Arc GIS software. The concentration distribution map shows that anomalous concentrations of C_1, was found in northern part of the study area (Fig. 3). The Carbon isotopic composition of $\delta^{13}C_{CH4}$ ranges between -27.9 to -47.1 ‰ and $\delta^{13}C_{C2H6}$ ranges between -36.9 to -37.2 ‰ (V-PDB) indicating that these gases are of thermogenic origin. Integrated anomaly plots between adsorbed light hydrocarbons and bacterial anomalies are shown in Figures 3. Composite anomalies for light gaseous hydrocarbons and hydrocarbon oxidizers anomalies are adjacent and follow the natural model. This implies significant microbial anomaly above the hydrocarbon reservoir with lower values for adsorbed soil gases.

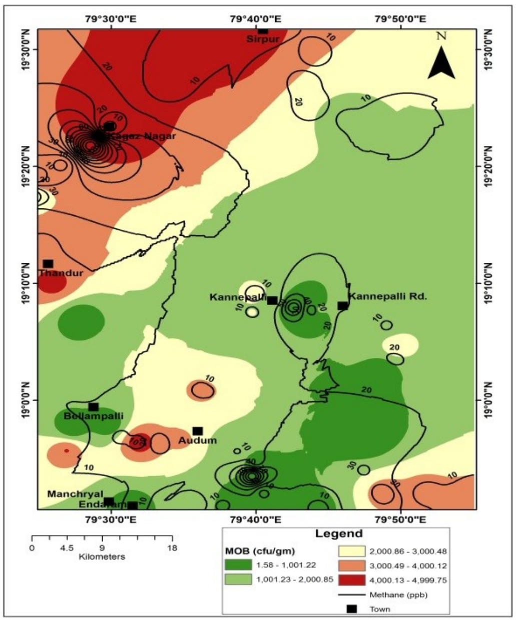

Fig. 3 Integrated Bacterial and Methane (C_1) anomaly map.

Conclusion

The microbial prospecting coupled with adsorbed soil gas studies, suggest that hydrocarbon micro-seepage of subsurface origin are present in the area. The correlation of adsorbed light gaseous hydrocarbons and hydrocarbon oxidizing bacteria suggests its efficacy as one of the potential tool in surface geochemical exploration of hydrocarbons. The experimental research work employing methodologies, which have potential to reduce risk in petroleum exploration, especially now when globally petroleum reserves replacement is becoming a challenge is of high significance. Hence this work is of good significance in the area of petroleum exploration.

Acknowledgements

The authors are thankful to Director, National Geophysical Research Institute, (CSIR) for granting permission to publish this work. We are thankful to Dr. Kuldeep Chandra, Former Executive Director, KDMIPE, Dehradun for his continuous support and constant guidance.

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