Exploration of Hydrocarbon in Proterozoic Basins using Geochemical Tracers

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Near-surface geochemical prospecting technique is used to detect the surface anomalies of hydrocarbons, which give the direct evidence of their occurrence in the subsurface (Jones and Drodz, 1983; Klusman, 1993; Tedesco, 1995). The light gaseous hydrocarbon concentration data in shallow soils can be used for i) preliminary assessment of hydrocarbon generation potential of a basin, ii) distinguishing productive and non-productive basins and iii) predicting possibility of oil and gas reservoirs in the area. The surface geochemical exploration data when prudently integrated with geological and geophysical analysis can form a better exploration tool to reduce exploration risk.

In the present study, one of the oldest Proterozoic Vindhyan basin was selected for hydrocarbon exploration. The Vindhyan basin is the largest Proterozoic basin in India with an area of >105 km^2. It is intra-cratonic basin comprising of shale, limestone and sandstone horizons with a thickness of ~4300m (Krishnan and Swami Nath 1959). Most of the Vindhyan are un-metamorphosed. Ray et al (2002) has reported the age of this basin is ~1600 Ma. The occurrence of organo sedimentary structures and fossils indicate that the basin may have potential source rocks for the generation of hydrocarbon. The basin is constrained by Great Boundary Fault and Narmada-Son lineaments. The combined gravity, magnetic and seismic studies reveal deepening of the basin towards southern margin (Jokhan Ram et al., 1996).

Soil samples were collected in the depth range of 1.2 to 3.5 m at intervals using metal hollow metal pipe by manual hammering to a required depth. The cores retrieved were wrapped in aluminum foils and sealed in poly metal packs. The sample number, core depth and GPS location (Latitude & Longitude) were marked on each sample in the field.

The light gaseous hydrocarbons were desorbed from soil core samples by treating 1gm of sample with orthophosphoric acid in vacuum. The CO_2 evolved from soil carbonates is absorbed in KOH solution and the desorbed light gaseous hydrocarbons are collected by water displacement in a graduated tube fitted with rubber septa. The volume of desorbed gases is recorded and 0.5ml of the gas sample is injected into Varian CP 3380 Gas Chromatograph fitted with Porapak-Q column, equipped with Flame Ionization Detector. The gas chromatograph was calibrated using an external standard with known concentrations of methane, ethane, propane, i-butane and n-butane. The quantitative estimation of light gaseous hydrocarbon constituents in each sample was made using

peak area measurement. The moisture content was determined and the gas concentrations are reported in ppb on dry weight basis. The accuracy of measurement of C_1 to C_4 components is < 1 ng/g.

The concentration of CH_4, C_2H_6, C_3H_8, iC_4H_{10} and nC_4H_{10} desorbed from the soils vary from 1-2500 ppb, 1-550 ppb, 1-180 ppb, 1-40 ppb and 1-30 ppb, respectively. The cross plots between C_1-C_2, C_1-C_3, C_2-C_3, C_1- C_4 and C_1- C_3 shows linear correlation (r ~0.9) between methane and higher hydrocarbons. This indicates that the light hydrocarbon components are generated from thermogenic source and the effect of secondary alteration during their seepage towards surface is insignificant. Concentration of methane falls in three groups i.e. >200 ppb, 100- 200 ppb and <100 ppb. The cumulative frequency distribution curves for C_1 and C_2^+ are bimodal and polymodal in nature.

Pixler (1969) proposed a variation diagram using the ratios of C_1/C_2 and C_1/C_3 to distinguish the non productive zone from the oil/gas producing zone. Ratios below 2 and above 60 are from non productive zone. These ratios clearly define the transition between biogenic and thermogenic gases. In the Pixler plot 70% of these samples fall in the oil window and rest in the gas window. Concentration of light hydrocarbon data plotted in Geological map shows the anomalous zone in the southern part of the basin. The geochemical study on the soil samples indicates that this part of the basin is a warm area for hydrocarbons and suggests further exploration using geophysical techniques.