



GEOCHEMICAL EVIDENCES OF TRACE METAL ANOMALIES FOR IDENTIFICATION OF HYDROCARBON MICROSEEPAGE IN THE IN NORTHERN PART OF PRANAHITA GODAVARI BASIN

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Abstract

The paper reports the role of hydrocarbon microseepage in surface alterations of trace metal concentrations. In this study trace metal alterations were mapped that appear to be associated with hydrocarbon microseepages in the oil/gas fields. The soil samples were collected from a depth of 1-2.5 m. Trace metals, such as scandium (Sc), vanadium (V), chromium (Cr), cobalt (Co), nickel (Ni), copper (Cu) in soil samples were analyzed using inductively coupled plasma-mass spectrometry (ICP-MS). The concentrations of V, Cr, Ni, Co were tremendously increased when they were compared with their normal concentrations in soils. The analysis of adsorbed soil gas showed the presence of high concentrations of C₂₊ (C₂H₆ and C₃H₈). Integrated studies of trace elements over adsorbed light gaseous hydrocarbons anomalies showed good correlation. The increase in the concentrations of trace metals, suggests a soil chemical change to a reducing environment, presumably due to the influence of hydrocarbon microseepage. This methodology could further integrated with other geo-scientific studies for identification of hydrocarbon potential of the area.

Key words: Hydrocarbons, microseepage, trace metal alterations, adsorbed soil gas, Pranahita Godavari Basin

Introduction

The long-term seepage of hydrocarbons, either as macroseepage or microseepage, can set up near-surface oxidation reduction zones that favor the development of a diverse array of chemical

and mineralogical changes (Donovan, 1974; Petrovic et al, 2008). The bacterial oxidation of light hydrocarbons can directly or indirectly bring about significant changes in the pH and Eh of the surrounding environment, thereby also changing the stability fields of the different mineral species present in that environment. These changes result in the precipitation or dissolution and remobilization of various mineral species and elements, such that the rock column above a leaking petroleum accumulation becomes significantly and measurably different from laterally equivalent rocks (Price, 1986). It is also believed that hydrocarbons along with inorganic components associated with oil are continuously migrating to the surface which forms the basis for surficial petroleum investigations with regard to trace metals (Petrovic et al, 2008). Anomalous amounts of vanadium, chromium, nickel, cobalt, manganese mercury, copper, molybdenum, uranium, zinc, lead and zirconium are positive indicators of petroleum deposits (Duschcherer, 1983). Trace elements concentrations have been used as indirect indicator for hydrocarbon microseepage (Schumacher, 1996; Madhavi et al, 2011; Rasheed et al., 2013). This paper reports the chemical alterations associated with trace metals in soils that are related to hydrocarbon microseepages in the study area of Pranahita Godavari Basin.

GEOLOGY AND STRATIGRAPHY OF THE STUDY AREA

The NW-SE trending Pranahita-Godavari (PG) is a large inter-cratonic Gondwana basin located in the eastern part of the Peninsular India. It is filled 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 Chintalputi, Godavari and Coastal sub-basin. Seismic studies across the Chintalputi sub-basin delineated

several basement ridges and depressions and provided a depth of Moho of 40 km (Kaila et al., 1990). 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. The Talchir Formation is 200-370 m thick consists of diamictite, rhythmite and green sandstone. Barakar Formation is 460 m thick consists of pebbles beds, feldspathic sandstone, carbonaceous shales and coal seams. Barren Measures are 60-800 m thick consists of feldspathic sandstone, shales and carbonaceous shales. The Kamthi Formation is about 400-500 m thick, succeeds the Barren Measures with gradational contact variegated sandy and calcareous clay and sandstones. The 250 m thick Maleri Formation consists of reddish brown to greenish gray clay, siltstone and argillaceous sandstone. Kota Formation is about 500-800 m thick and includes cross-bedded sandstone with plenty of flora, fish and dinosaur bearing limestone and clay. Gangapur Formation is about 250 m thick, consists of sandstone, siltstone and different flora. Chikiala Formation is about 275 m thick, consists of conglomerate sandstone, siltstones and ferruginous sandstone.

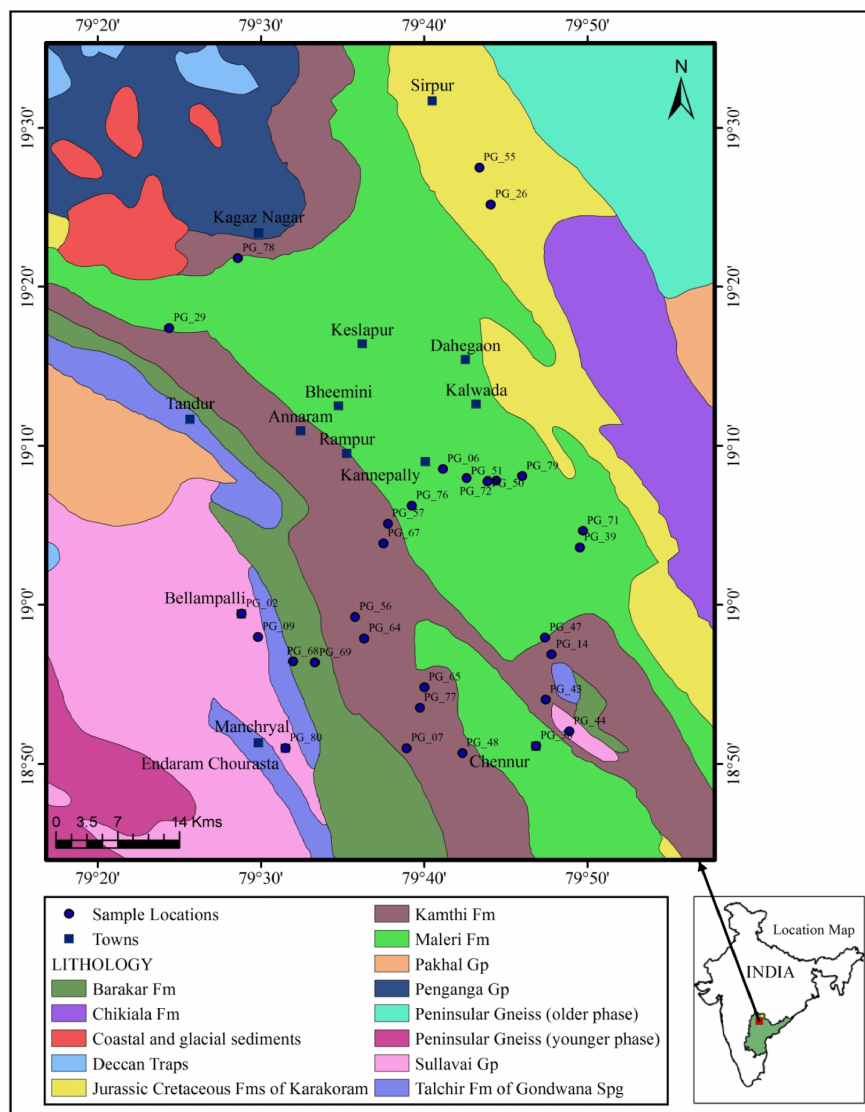


Fig.1. Geological map of Pranhita-Godavari Basin with sample locations (MODIFIED AFTER GSI, 1994).

MATERIALS AND METHODS

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.

ICP-MS Analysis:

The chemical analyses of the soil samples were carried out using ICP-MS (Perkin-Elmer Sciex Elan DRC II) at CSIR-NGRI, Hyderabad. ICP-MS is a type of mass spectrometry based on coupling together an inductively coupled plasma as a method of producing ions (ionizations) with a mass spectrometer as a method of separating and detecting ions. ICP-MS is highly sensitive and capable of determination of a range of metals and several non-metals at concentrations below one part in 10^{12} .

Results and Discussion

The concentrations of V (71.9 to 262.28 mg/kg), Cr (87.66 to 240.94 mg/kg), Co (8.03 to 41.65 mg/kg), Ni (39.68 to 117.99 mg/kg), Cu (30.3 to 98.08 mg/kg) and Zn (90.03 to 590.69) were found in the soils of the study area. It has been observed that the concentration of trace elements is tremendously increased when compared with normal concentrations in soils. The trace element concentration distribution maps of Nickel in the study area is shown in Figures 2 indicate that this anomalous concentration of these trace elements is found in Southern part and North western parts of the study area. This increased concentration of trace metals, suggests the chemical change that the soil has gone to a reducing environment, presumably due to the influence of hydrocarbon microseepage (Tedesco, 1995).

Increased amounts of soluble Ni, V, Cu, Cr, Zn and Co have been observed in the reducing environment caused by the seepage of hydrocarbons. In the reducing environment solubility of metals increases and transport occurs. Due to hydrodynamic flow, soluble elements move around the soil, although they do not leave the reducing area (Tedesco, 1995). The boundary is formed between the reducing and oxidizing zone by the deposition of carbonate, oxide and sulphide minerals. Several metals including Ni, V, Cu, Cr, Zn and Co are mobilized in soils and

accumulated around the hydrocarbon anomaly when impeded hydrocarbon accumulation leads to reducing condition (Nissenbaum and Swaine, 1976). This feature in combination with other geochemical, geophysical and geological techniques may help to understand the characteristics of the petroleum reservoir.

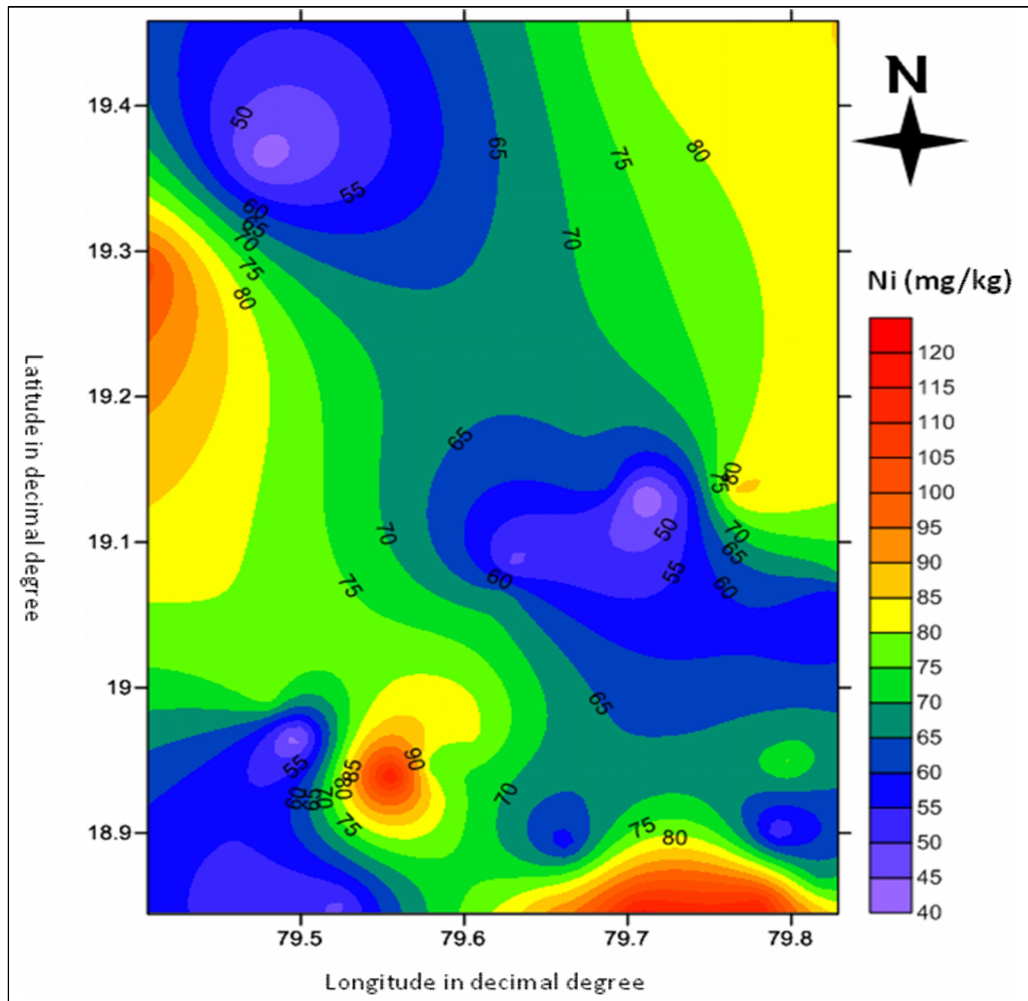


Fig. 2 Concentration distribution map of Nickel in the study area.

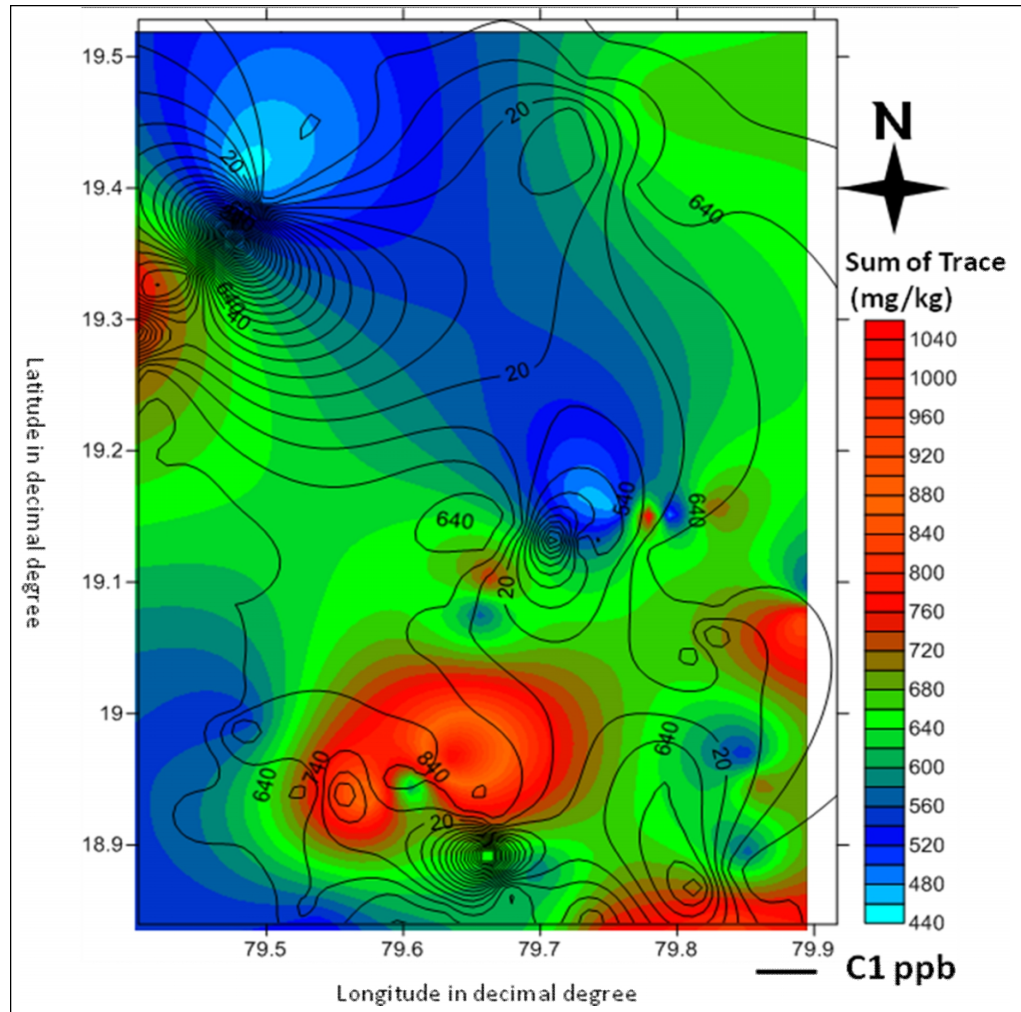


Fig. 3 Integrated maps of sum of concentrations of trace elements and adsorbed soil gas of the study area.

The adsorbed soil gas anomalies were adjacent to the trace metal anomalies. By observing the composite maps of hydrocarbons and trace elements, (Figure 3) clearly indicate that trace elements are accumulated around the hydrocarbon anomalies, creating a halo pattern (Siegel, 1974). Duchscherer (1983). Enrichment of trace elements seen around the hydrocarbon anomaly helps verify the correlation between microseepage and trace elements concentrations. That enrichment of trace elements around the hydrocarbon anomalies can suggest that trace elements can be a pathfinder for hydrocarbon microseepage paths.

Conclusion

The increase in the concentrations of trace metals, suggests a soil chemical change to a reducing environment, presumably due to the influence of hydrocarbon microseepage. Enrichment of trace elements seen around the hydrocarbon anomaly helps verify the correlation between microseepage and trace elements concentrations. This methodology could further integrated with other geo-scientific studies for identification of hydrocarbon potential of the area. That enrichment of trace elements around the hydrocarbon anomalies can suggest that trace elements can be a pathfinder for hydrocarbon microseepage paths.

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