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Geoscientific study to locate hydrocarbon prospective zones in a part of Cauvery Basin using Remote Sensing and GIS techniques

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IRS-P6 LISS III geocoded FCC data in conjunction with Survey of India toposheets (1:50,000) and field inputs were used for thematic mapping. Geomorphic units identified through visual interpretation of FCC include: fluvio-marine sediments, flood plain, coastal plain, beach ridges, swale and palaeo-channels. In addition, lineaments were also mapped. Based on the geomorphology, geology, DEM, subsurface faults and lineaments hydrocarbon prospective zones in a part of Cauvery Basin has been identified. The demarcated prospective zones were compared with the gravity and magnetic data as well as topographical and structural maps.

[**Keywords:** Hydrocarbon prospective zones, remote sensing and GIS, DEM, Deep sheeted faults, Cauvery Basin]

Introduction

Hydrocarbon is a valuable and critical natural non-renewable mineral resource and it requires careful use. Hydrocarbon exploration and development require large amount of multidisciplinary data from various sources. As hydrocarbon occurrence is a subsurface phenomenon, its assessment is mainly based on indirect analysis of some directly observable terrain features such as geological, geomorphological and structural characteristics[1] Satellite remote sensing provides synoptic view, which is helpful in identification and delineation of various lineaments, land forms, structural elements and terrain features which are significant indicators of hydrocarbon potentials. Remote Sensing and Geographical Information System (GIS) techniques are widely used in hydrocarbon potential mapping [2].

In the sedimentary terrain availability of hydrocarbon is limited and its occurrence is essentially confined to fractures and faults. The detailed stratigraphy, lithostratigraphy, reservoir characteristics, environment of sedimentation and palaeoclimate studies were carried out by many different authors in various places[3]. GIS and remote sensing applications have been used by limited workers in delineation of hydrocarbon potential zones[4.] Assessment of hydrocarbon resources in Cauvery Basin is very much necessary to know its availability for future development. With this objective, an integrated approach of geology, geomorphology and lineament mapping has been adopted using remote sensing and GIS techniques for delineating hydrocarbon potential zones in Cauvery Basin.

Materials and Methods

The Cauvery Basin lies between North latitudes 09^o 03’ 00” - 12^o 10’ 00” and East Longitudes 78^o 09’30” - 79^{o}54’15”. It covers an area of about 25,495 km2. Location of the study area is as shown in Fig 1. Cauvery basin is one of the pericratic rift basin in East coast of Tamil Nadu. It consist many rifts and basins. The surface exposures of sedimentary rocks had been studied and mapped by Blanford of Geological Survey of India (GSI) in 1865 [4] which had been correlated with the Cretaceous formations of England and France because of existence of rich ammonite fauna. Geology of the study area is shown in Fig.1. It is now known that the exposed sedimentary sequence

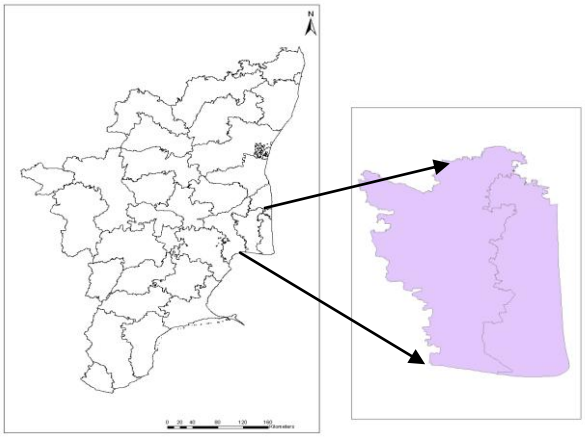

Fig 1—Map showing location of the area

of Cretaceous/Paleocene rocks. The sedimentary section contains a number of transgressive-regressive episodes. The lithology varies from conglomerate, sandstone and shale to limestone and dolomites.

The cretaceous exposures are generally observed in the Ariyalur-Pondicherry sub-basin. However in rest of the places it is covered with quaternary sediments.

The description of stratigraphy of the Cauvery Basin appeared in many publications[5-9] In the whole sedimentary groups three groups are confined to Cretaceous, namely Uttatur, Trichinopoly and Ariyalur in their order of superposition. The maximum transgressive pulses are seen in mid-albian, late albian, middle to late Cenomanian, early mid-Turonian, late Coniacian-Santonian, late companion and early-late Maastrichtian times[10] This resulted in finer clastics being deposited all over the regional caprock facies. Interspersed regressive events marked the deposition of reservoir facies of mainly siliciclastic rocks with pronounced unconformities at the top of pre-Albian, Albian, early mid-Turonian, early Santonian and early Maastrichtian times. Effective source rock facies remained in the synrift sequence I and II (mostly early cretaceous) during which anomix conditions prevailed in the basin for better preservation of the hydrocarbon source[1]. In Cauvery Basin, Andimadam formation, Bhuvanagiri formation and Kamalapuram formation have a very good reservoir rocks.

Survey of India (SOI) toposheets 58 M, 58 N and 58 K on 1:2,50,000 scale were used for the preparation of base map. IRS P6 LISS III geocoded False Color Composite, of band combination 234 pertaining to 2003 was also used for preparation of other thematic maps. Secondary data such as magnetic data, gravity data, subsurface faults and soils particulars were obtained from various organizations. The IRS FCC images were visually interpreted based on photographic and geotechnical elements such as tone, texture, size, shape, association, pattern, drainage, erosion etc. Based on the visual interpretation of images various geomorphological units and structural features like lineaments were delineated. Subsequently field checks were conducted in key areas to check the veracity of remote sensing data and to incorporate field knowledge onto the map. The drainage map was initially derived from SOI toposheets and subsequently updated using satellite images. Drainage map Fig.2 was digitized as a line coverage showing the entire stream network. Lineament mapping was

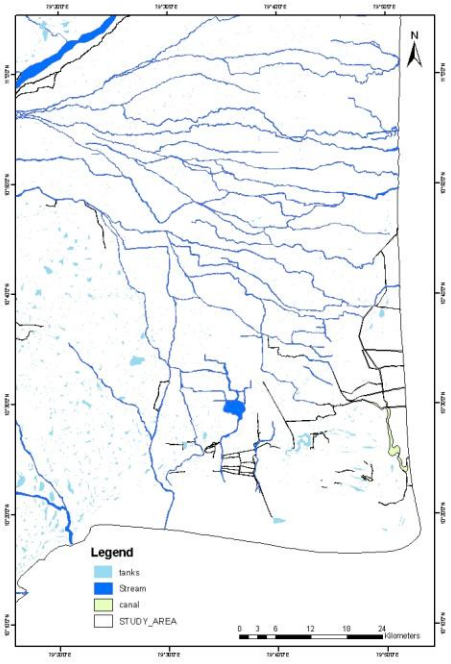

Fig. 2—Map showing Drainage Characteristics of the area

done on the basis of changes in topographic slopes, relief patterns, crest type, drainage type and image characteristics. The single most dominant factor for picking up lineaments on the satellite data is the linearity of tone/texture. Presence of natural vegetation along the lineaments was also one of the key recognition elements on the satellite data.

Results and Discussion

Geomorphology map helps to identify the various geomorphic units and groundwater occurrence in each unit. Geomorphological map was prepared using IRS LISS III satellite data. Regionally the basin has been classified into various geomorphic units which are shown in Fig 3. Pediment is a gently sloping area with erosional form bed rock, situated in between plain consist of a maximum locations. Most part of the study area is covered with Fluvio-marine sediments. The south western portion of the study area is covered with Mio-Pliocene uplands.

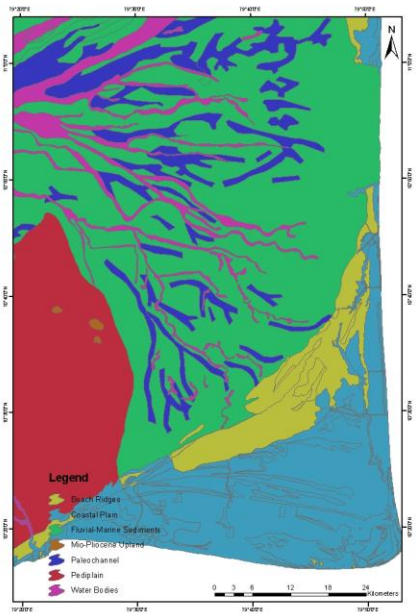

Fig.3—Map showing Geomorphic Characteristics of the area

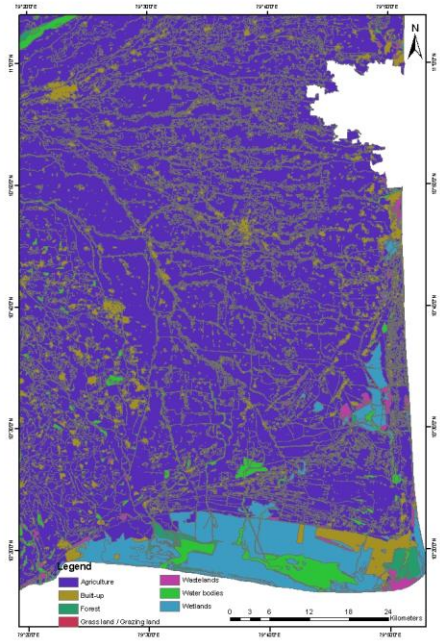

Fig.4—Map showing Landuse Characteristics of the area

The land use of the study area is characterized by a mixture of forest cover, agriculture activities, wasteland and built up area. Visual image interpretation technique was carried out to prepare land use / land cover map which is shown in Fig 4. The geomorphology map, geology map and lineament map were prepared using modules available in Arcview GIS software. Polygon topology was built for geologic and geomorphic units, after assigning a unique id for every polygon feature. For lineament map, the coverage was digitized as line coverage giving common entity to all the lineaments. Based on the image characteristics, field data, conventional data, lithology, different types of faults and morphology, finally hydrocarbon potential zones were identified.The chief source rock for the commercial accumulations of oil and gas in Cauvery Basin is primarily the shales of Andimadam formation of early Cretaceous age. These shales are identified in deep wells drilled in all the sub-basins. These are reported the saddles of the NE trending horsts has been conceptualized, that would have caused the observed structural grain and the disposition of the horsts and grabens[11] The observed structural pattern is also inferred to have resulted from compressional and extensional tectonics experienced in this part of the Indian Peninsular shield during the evolution of the eastern and western continental margins of India[12]Cauvery Basin is a province of dispersed petroleum habitat in space and time. Commercial accumulations have been encountered in all geological formations from Precambrian fractured basement to Oligocene multistacked sandstone reservoirs. But the pools are small, discrete, isolated and under-charged with water contact being seen in almost all the pools Pre-albian and albian shales are established as the main source sequence for all the hydrocarbon to be a good potential source from geochemical analysis, which is capable of designating it as a pod of mature source rock for oil and gas accumulation in the basin [13] Basin floor tectonics is described by Venkatarangan, have some bearing on the critical movement for the Andimanam/Nannilam

petroleum system[14] transcurrent faulting has been suggested in the basin floor frame work. A basic wrench corridor nearly aligned north-south and connecting accumulations in the basin. These shales are flood plain, coastal plain, delta deposits and attain maximum thickness in the deeper parts of the sub-basin. It has good organic richness and thermal maturity. It is capable of generating both liquid andgaseous hydrocarbons. There is no dearth of reservoirs though they are thin and discrete. Coarser clastics within Andimadam and Bhuvanagiri formations of lower Cretaceous age are found to contain both oil and gas in several fields. However, these formations are tight and calcareous with poor porosity and permeability and occur at depths of more than 3000m.

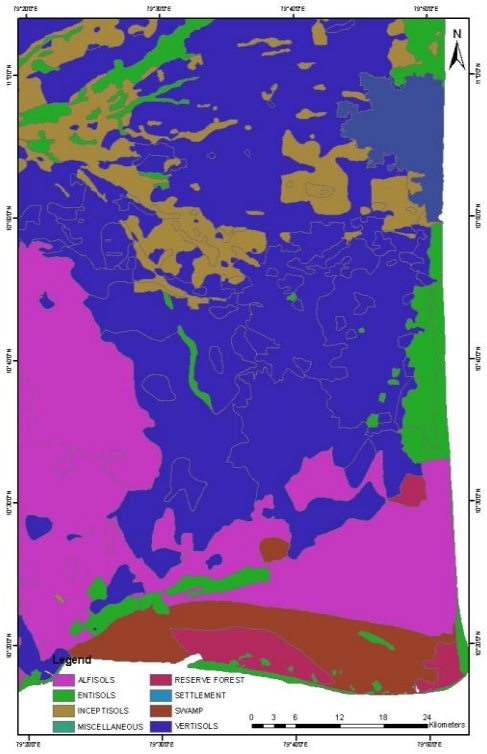

Fig.5—Map showing Soil Characteristics of the area

Soil characteristics of a terrain are important since they meet the basic needs of all agriculture production and rainwater percolation[15] The types of soil that occur are derived from a wide range of geological materials. Knowledge about the types of soil is of primary importance for agriculture planning to maximize the production. Soil map of study area prepared based on the survey and landuse organization of Tamil Nadu agricultural department indicates four different categories of soils (Fig.5).

Lineaments, being surface manifestations of structurally controlled linear or curvilinear features, are identified on the satellite imagery by their relatively straight tonal alignments[16]. A lineament is defined as large-scale linear feature, which expresses itself in terms of topography of the underlying structural features. Lineaments can be fractures, straight course of streams and vegetation patterns[7] In Cauvery Basin, NE-SW, NW-SE, N-S and E-W lineaments are observed but NE-SW and N-S lineaments are most favourable zones of hydrocarbon accumulation. Because NE-SW trends are parallel to the trend of the Eastern Ghats and N-S lineaments are due to block faults or release fractures[17] E-W lineaments are also observed in the Cauvery Basin. Lineament density map shows the excellent indicator which clearly depicts the maximum existing oil gas wells are located in the NE-SW lineaments and E-W lineaments or archings[2]. Lineament and Lineament density map of the study area are is shown in Fig 6.

The thematic maps derived through the interpretation of satellite data i.e. geomorphology, lineament, drainage and geology were digitized, edited and saved as shape files in Arcview GIS software. The lineament and drainage maps were digitized as line coverage whereas geomorphology, Lineament and geological maps were digitized and saved as polygon coverage, assigning unique polygon IDs to each geomorphologic, lineament and geological units.

Thematic maps were then projected to a common UTM projection system so as to subsequently superimpose in GIS using its overlay sub-module to demarcate hydrocarbon prospect zones based on the above themes Fig 7. Integration of thematic maps led to the demarcation of hydrocarbon prospect map which qualitatively defines the prospect zones for future hydrocarbon development in Cauvery Basin.

Many authors analyzed and interpreted the gravity and magnetic data of Cauvery Basin Magnetic data was used to determine the limit of the basin depth of the basement and basement linearities which shows the highs and lows of the areas.[1-6] The gravity data exhibits the gravity anomalies of some existing oil/gas wells as well as newly identified zones.

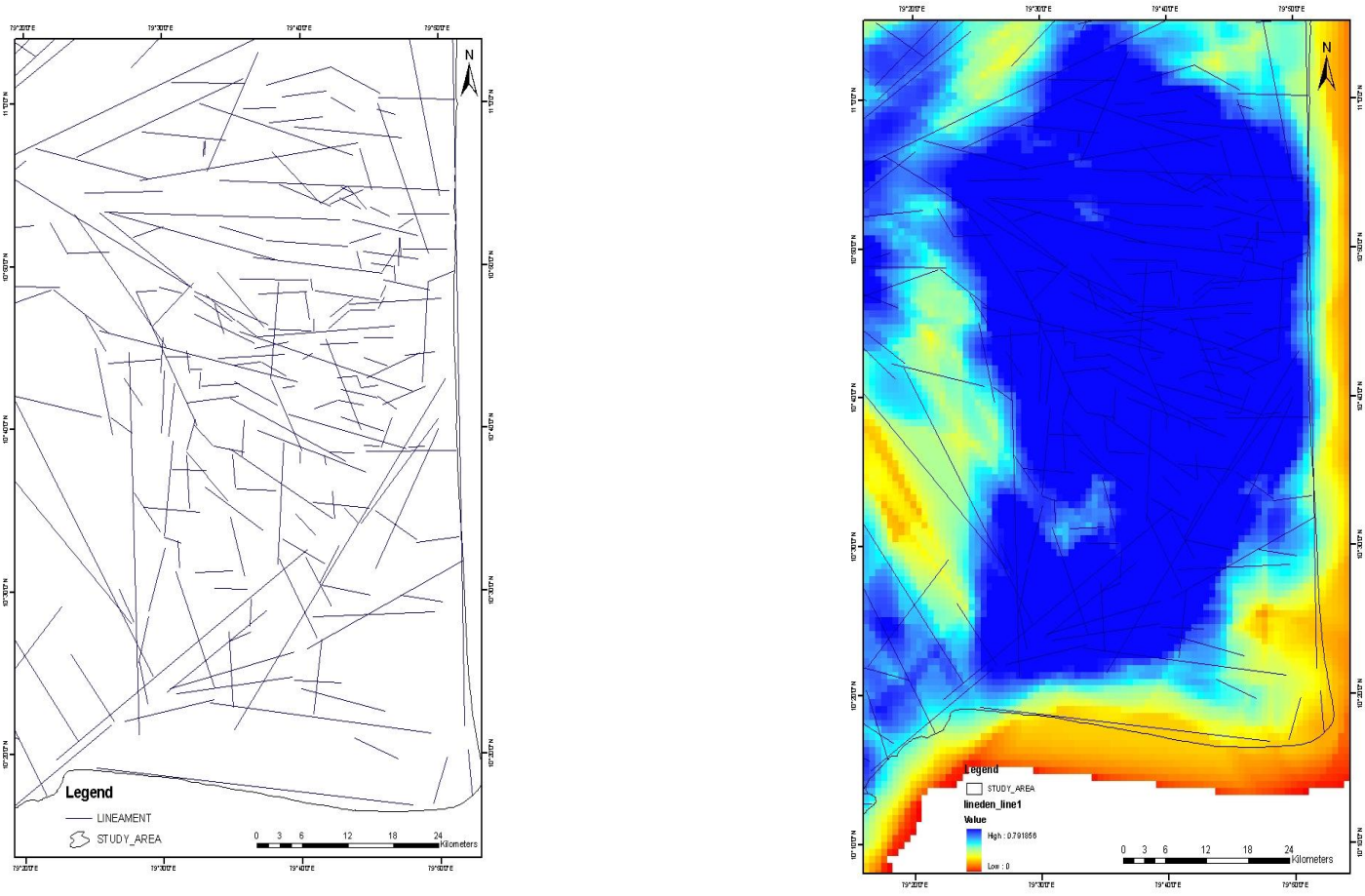

Fig.6—Map showing Lineament and Lineament Density of the area

Conclusion

The study has demonstrated the utility of Remote Sensing and GIS techniques in delineating hydrocarbon potential zones in highly variable terrains representing various geomorphic features/landforms. Study reveals that wherever fluvio marine sediments are intersected by the lineaments are more prominent locations for oil/gas. Above details are shown in the vector layer and indicate from the Barremian to recent age there is connectivity, because the faults were in this region active from the Late Jurassic. Lineaments that are present on the sedimentary terrain and cut across some of the tributaries may also prove to be faults are still active in this locations that are prove to the subsurface reservoirs and surface lineaments have good connectivity The geomorphic and lineaments units in the area corroborate with the existing oil/gas wells.

The hydrocarbon prospects map generated through the integration of geomorphological, geological and lineament mapping may be useful for planners and decision makers for initiating hydrocarbon development in the area. In this paper clearly depicts Remote Sensing and GIS tools were cost effective and time consuming in invention of new oil/gas locales.

Table-1—Overlay analysis and Score index

S.No	Overlay layers	Score	Priority
1.	NS Lineament +Magnetic High + Gravity High	80	High
2.	E-W Lineament + Magnetic High + Gravity High	70	Moderate
3.	NE-SW Lineament + Magnetic High + Gravity High	90	Very High
4.	NW-SE Lineament + Magnetic High + Gravity High	40	Low
5.	NS Lineament +Magnetic Low + Gravity Low	50	Moderate
6.	E-W Lineament + Magnetic Low + Gravity Low	50	Moderate
7.	NE-SW Lineament + Magnetic Low + Gravity Low	60	Moderate
8.	NW-SE Lineament + Magnetic Low + Gravity Low	40	Low
9.	NS Lineament +Magnetic High + Gravity Low	50	Moderate
10.	E-W Lineament + Magnetic High + Gravity Low	60	Moderate
11.	NE-SW Lineament + Magnetic High + Gravity Low	60	Moderate
12.	NW-SE Lineament + Magnetic High + Gravity Low	40	Low

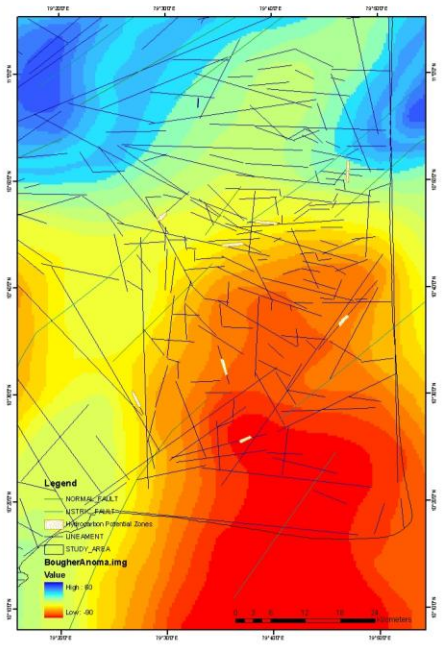

Fig.7—Map showing Integration of data with Hydrocarbon potential zones

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