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Prospectivity of oil in Jaisalmer Basin – An analysis

ABSTRACT:

Jaisalmer Basin is a category-I basin, has proved presence of gaseous hydrocarbon. Indication of liquid hydrocarbon has been found in some of the wells; however commercial occurrence of oil/ condensate is yet to be established. The objective of current study is to analyse the oil from different fields and establish the oil to source and oil to oil correlation for better understanding of oil accumulations in the basin.
Biomarkers and stable isotopes are useful for genetic oil-oil and oil-source rock correlation. Oil samples has low V/V+Ni, high Pr/Ph and biomarkers (hopanes and steranes) ratios suggest the oils to be derived from dominantly terrestrial organic matter deposited in oxic environment. CSIA profile of n-alkanes of oils from different fields show similar trends and are correlatable, whereas CSIA profile of studied EOMs show the dominance of even over odd carbon numbers and similar isotopic trend.

Key words: Category-I Basin, Pr/Ph, Biomarkers, CSIA profile, EOMs

INTRODUCTION:

The objective of current study is to analyse detailed geochemical characteristics of crude oils found in different gas fields of Jaisalmer Basin, Rajasthan, for genetic correlation of oil to oil and for possible oil-source correlation. Jaisalmer Basin has a gas rich petroleum system. Very limited data is available from few wells of different fields viz. Chanwarwala Dara, Chinnewala Tibba, Ghotaru, Bankia and Dandewala fields (Fig.1). Representative wells from each of the field has been considered for geochemical characterization of the oil samples. The analysis of the samples includes biomarkers, sterane/hopane cycloalkane biomarkers, carbon isotopic composition, percentage of aromatic protons and vitrinite reflectance values etc. in few wells complete data set was not available that's why available data has been used for analysis.

Most of the liquid hydrocarbons shows in Jaisalmer Basin are in Mesozoic sequences. The distributions of oil/gas in the wells are in different formations having quite complex mechanism of entrapment in the region. Probably the entrapment mechanisms are governed by faults. Shows of liquid HC in Chanerwala Dara Field is from Baisakhi-Badesir Formation, Chinnewala Tibba from Lower Goru and Pariwar Formations, Ghotaru formation from Lower Goru Formation, Bankia and Dandewala from Pariwar Formation.

Several geochemical parameters are used to distinguish different type of oil, based on their biomarker characteristics. Differences in the ratio of pristane to phytane reflect variations in the degree of oxidation during the early stages of chlorophyll degradation (Powell & Mckirdy, 1973). Thus the formation of phytanic acid, the precursor of pristane, should occur to a greater extent on land during the initial, aerobic stages of plant decay than in an aquatic environment where totally anaerobic decomposition is more likely (Shanmugam, 1985).

The oil samples from the fields are mainly light/condensates with API gravity ranging from 40.0 to 55.0°, with traces of asphaltene content and very low pour point (<0°C). These oils have very low nickel concentration (0.01 to 0.03 ppm) and vanadium in the range of 0.09 to 0.46 ppm. The ratio V/V+Ni is from 0.01 to 0.33 which shows oxic depositional environment for studied oils (Lewan, 1984). The bulk isotopic parameters for comparing saturate and aromatic fractions of studied oils did not show consistent results as the saturate fraction was very much volatile and evaporated even during sample preparation. The CSIA profile also indicates the presence of n-alkanes upto C12 only in CT-A,

CT-B and CT-C oils. However, the CSIA profile of Chanwarwala dara and Bankia indicates predominantly terrestrial source input.

OIL GEOCHEMISTRY OF DIFFERENT FIELDS:

Ghotaru Field: Ghotaru is gas Field **(Figure.1),** is located on a four way anticlinal closure on Jaisalmer Mari High. The field is characterized by gas occurrences at Tertiary as well as Mesozoic sequences. The oil presence is reported from Lower Goru Formation (Upper Cretaceous). General geochemical characteristics include: low sulphur, asphaltene, high wax and deficient of gasoline and kerosene range hydrocarbons indicates loss of lower hydrocarbons because of alteration. Presence of normal alkane ranging from nC14 to nC33 with maxima at nC23 indicates predominantly terrestrial organic matter, however low Pr/Ph ratio indicates contribution of algal matter. Low Pr/nC17 ratio may indicate the fluvio-marine condition of organic matter. N-alkane finger printing shows the oil is not a biodegraded or water washed oil.

Chinnewala Tibba Field: The field is located west of Ghotaru Field **(Figure.1)** on Jaisalmer Mari High. This field is characterized by presence of gas along with light crude from Lower Cretaceous (Pariwar & Lower Goru Formation). The crude sample of the field is characterized by low pour point and high API (44.3°), very low concentration of wax and asphalt. Predominance of n-alkanes in the range of C12-C18 and High Pr/Ph ratio suggest terrestrial source (Shale and Coal type) deposited in fluvio-deltaic environment, the same observation is supported with $\delta^{13}C$ whole oil, dominance of C29 steranes over C27 and C28.

Bankia Field: This gas field is located on Jaisalmer Mari High with gas presence in Lower Goru Formation unlike Ghotaru and Chinnewala Tibba Gas fields with gases from Lower Goru and Pariwar both the formations. During testing in Pariwar Formation one of the well of the field liquid hydrocarbons has been reported. The crude oil has low pour point, low asphaltene, low sulphur and high API. The sample has predominantly saturates over aromatics and High Pr/Ph ratio indicates Terrestrial source of organic matter deposited in deltaic environment indicated by low Pr/nC17 ratio and presence of oleanane (indicated influence of Higher Plants).

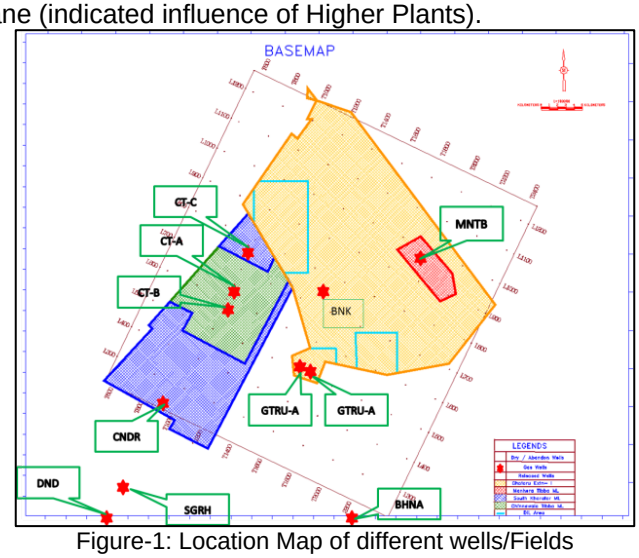

Figure-1: Location Map of different wells/Fields

SOURCE ORGANICS AND DEPOSITIONAL ENVIRONMENTS:

Normal alkane and isoprenoids are considered as important biological markers. n-alkane distribution gives valuable information on the source input. Relative contents of pristine, phytane and cyclic biomarkers depend on nature of source organics and environment of deposition. The isoprenoid pristane (Pr) and phytane (Ph) are most abundant and their relative amounts show source organic input, environment of deposition and maturity. Low pristane to phytane ratio (<1) indicates anoxic environment of deposition and predominantly marine input whereas high value (>3) indicates oxic environment of deposition and predominantly terrestrial input (Mackenzie et. al., 1981).

The CT-A, CT-B and CT-C oils show the presence of n-alkanes up to C18 only. The Pr/Ph ratio varies from 3.3 to 7.9 in the studied oils. Pr/nC17 ratio varies from 0.24 to 1.2 and Ph/nC18 ratio is low (0.12-0.38) indicating terrestrial organic matter input deposited in oxic environment (Shanmugam, 1985). The cross plot of Ph/nC18 vs. Pr/nC17 **(Figure-2)** also indicates that the source rock for these oils are rich in terrestrial organic matter and were deposited in oxic environment with moderate maturity of the source. Ratio of (Pr+nC17)/(Ph+nC18) is used for genetically related source organics. Based on these ratios, the oils from CT-A and CT-B (ratio: 2.6 to 3.2) are correlated. The oils from CT-C, CNDR and BNK (ratio: 1.24 to 1.50) are also quite similar.

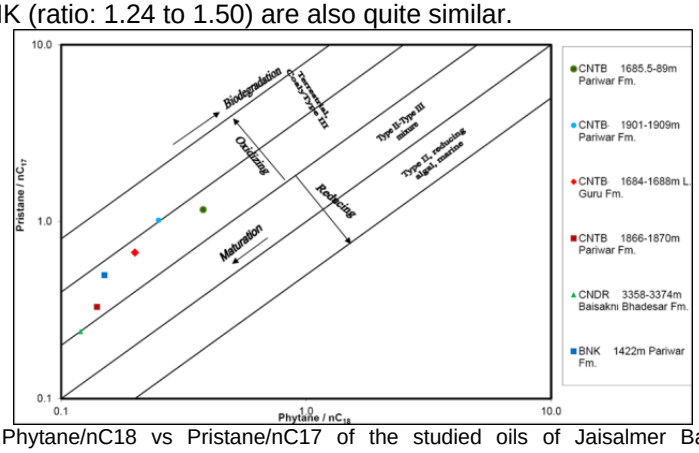

Figure-2: Cross plot of Phytane/nC18 vs Pristane/nC17 of the studied oils of Jaisalmer Basin showing depositional environment, maturity and type of organic matter

The triterpanes and sterane mass chromatograms (m/z 191 and m/z 217) of these oils have similar fingerprints. The studied oils are characterized by the presence of ubiquitous hopanes **(Ourisson et al., 1984)** and show predominance of C30 hopane over C29 hopanes (C29H/C30H ratio: 0.50 to 0.91) suggesting clay rich source organics for these oils. The oil from well CNDR show predominance of C29 over C30 (C29H/C30H ratio: 1.41). These oils show the absence of bicadinanes and oleanane and the studied oils show presence of homohopanes C31 to C35 suggesting contribution from C35 hopanoids in prokaryote microorganisms **(Hunt, 1995)**. Sterane fingerprints (m/z 217) show dominance of C29 steranes over their C27 and C28 homologues. The ternary diagram **(Figure-3)** showing the relative abundance of C27 ,C28 and C29 regular steranes for these oils shows terrestrial source organic input **(Huang, Wen-Yen and Meinschein W.G., 1979)**. The cross plot of Pr/Ph and C27/(C27+C29) steranes ratios also suggest predominantly terrestrial source input for the source rocks of studied oils which were deposited in oxic conditions **(Figure-4)**.

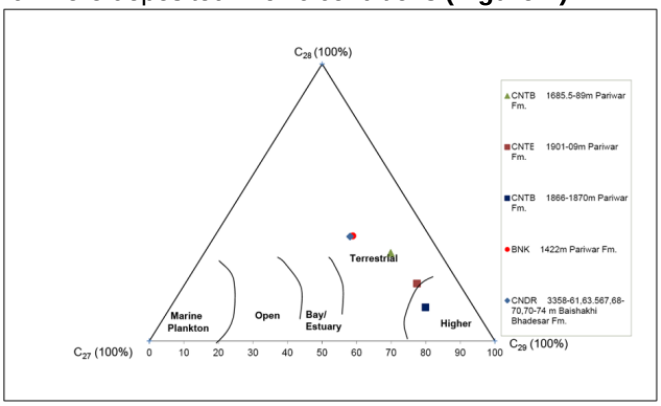

Figure-3: Ternary diagram of regular C27 ,C28 and C29 steranes of oils of Jaiselmer Basin showing type of source organic matter

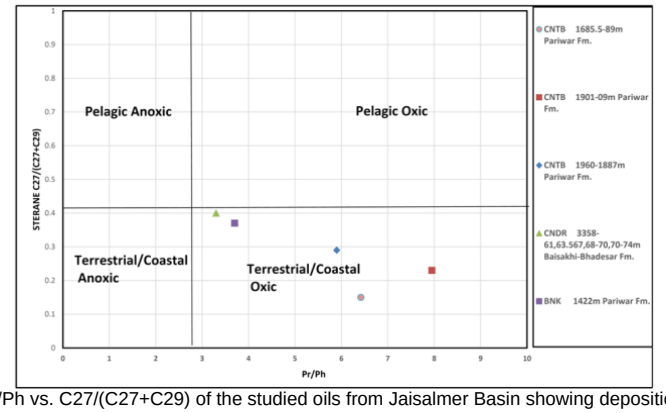

Figure-4: Plot Pr/Ph vs. C27/(C27+C29) of the studied oils from Jaisalmer Basin showing depositional environment

MATURITY LEVEL OF OILS/CONDENSATES:

The maturity level of oils has been assessed from the extent of isomerization of cycloalkane biomarkers of hopane and sterane classes. The biomarker range hydrocarbons for maturity assessment are C32 hopane, S/S+R, Ts/Ts+Tm, C30 moretane/C30 hopane, C29 sterane S/S+R and C29 sterane ββ/ββ+αα **(Figure-5)**.

the Hopane isomerization ratios C32 S/S+R for most of the oils have attained or are close to equilibrium values (0.51 to 0.60) suggesting maturity more than 0.60 VRo **(Schoell et. al., 1983 and Zumberge, 1987b)**. The C30M/C30H ratio in the studied oils varies from 0.09 to 0.20 which indicates moderate maturity (0.16 to 0.21) **(Seifert and Moldowan, 1980 and Mackenzie et al., 1980)**. The sterane isomerisation ratios C29 sterane S/S+R (0.38 to 0.52) and C29 sterane ββ/ββ + αα (0.46 to 0.68) for studied oils show wide variation in their values and are low to moderately matured **(Seifert and Moldowan, 1986)**. The ratio Ts/Ts+Tm range between 0.38 to 0.48 represent low to moderate maturity **(Seifert and Moldowan, 1978)**. The biomarker maturity is also supported by VRc values (0.70 to 0.89) calculated from distribution of various triaromatics i.e. phenanthrene and isomers of methyl phenanthrene.

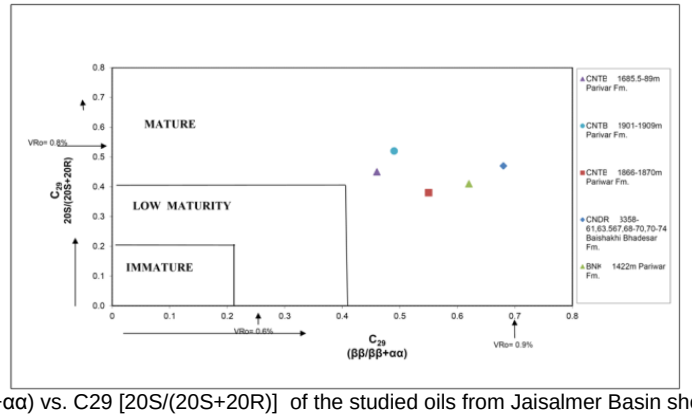

Figure-5: Plot C29 [ββ/(ββ+αα) vs. C29 [20S/(20S+20R)] of the studied oils from Jaisalmer Basin showing their maturity

COMPOUND SPECIFIC STABLE CARBON ISOTOPIC ANALYSIS (CSIA):

Compound specific stable carbon isotopic analysis was performed on n-alkanes in the saturated hydrocarbons of oils/condensates from Jaisalmer Basin to predict the depositional environment and their correlations **(Peter and Moldowan,1993, Waples and Curiale, 1999, Peters and Fowler, 2002)**. Among the studied oils, only oils from BNK and CNDR show the normal CSIA profile. The other studied oils from wells: CT-A, CT-B and CT-C are very light or condensates in nature and do not show isotopic profile beyond nC18. The CSIA profile of studied oils are given in **Figure-6.**

A slight negative slope of n-alkane CSIA profile of studied oils/condensates indicates terrigenous source input. This negative slope fingerprint has been described as characteristic of crude oils derived from deltaic and terrigenous organic matter **(Bjorφy et al., 1991; Wilhelms et al., 1994; Murray et al., 1994; Xiong et al., 2005 and Samuel et al., 2006).**

The CSIA profile of n-alkanes of oils from CNDR (Baishakhi-Bhadesar Fm.) and BNK (Pariwar Fm.) show similar trends and are correlatable.

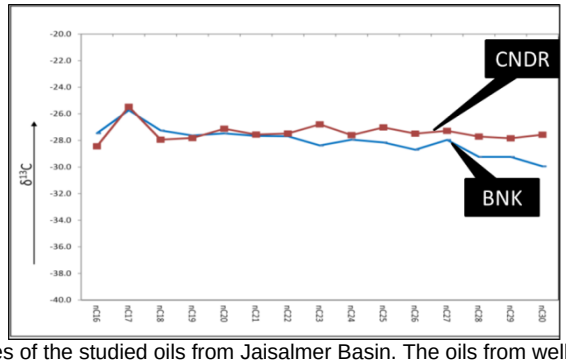

Figure-6: CSIA profile of n-Alkanes of the studied oils from Jaisalmer Basin. The oils from wells: Bankia (Pariwar Fm.) and Chanwarwala Dara (Baishakhi Bhadesar Fm.) are isotopically correlated.

CONCLUSIONS:

- The studied oils from Jaisalmer Basin are light/condensates. The low V/V+Ni, high Pr/Ph and biomarkers (hopanes and steranes) ratios suggest the oils to be derived from dominantly terrestrial organic matter deposited in oxic environment for the studied oils. The VRc values of the studied oils indicate low to moderate maturity.
- The CSIA profile of n-alkanes of oils from CNDR (Baishakhi-Bhadesar Fm.) and BNK (Pariwar Fm.) show similar trends and are correlatable. A slight negative slope indicates the deltaic and terrigenous organic matter. It also suggests that long distance migration has taken place in the field from Shahgarh low to our fields.
- The low to medium Pr/Ph ratio in the studied sediments suggesting
  Sub-oxic to oxic environment of deposition. These sediments show low to moderate maturity level.

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