PaperID   **AU194**

Author   **Mallikka Vaidyanathan** , **Regional Geoscience Lab**, **ONGC, Chennai** , **India**

Co-Authors   **Dr. B.G.Goswami**

Establishing two different Petroleum systems, using Biomarker techniques in, Pallivaramangalam Field, Nagapattinam Sub Basin, Cauvery Basin

Abstract

Biomarker studies of Source rock extracts and liquid hydrocarbons, is a useful correlation tool to determine the existence of different kinds of petroleum systems. Biomarker fingerprints of the Source rock extracts from 3 wells, well-D, well-E & well-G and the liquid hydrocarbons from 7 wells, well-A to well-G, of Pallivaramangalam field, in Nagapattinam Sub Basin, Cauvery Basin, were used to establish the existence of two kinds of Petroleum system with different Source organic matter input of the Source rock(s) and their correlation with the liquid hydrocarbons.

Introduction

Biomarkers are a group of compounds, primarily hydrocarbons, found in oils, rock extracts. Biomarkers consist of complex organic molecules whose chemical structures can remain largely unchanged during the processes of diagenesis and oil generation. This often allows them to be traced back to the original molecules in once living organisms. For this reason they are often called molecular fossils.

Biomarkers have a variety of applications in petroleum exploration. When samples of oil and candidate source rocks are available, biomarkers can be used to make oil-source rock correlations, or when samples of source rocks are not available, the biomarker distribution in an oil can be used to infer characteristics of the source rock that generated the oil without examining the source rock itself. Specifically, biomarkers in an oil can reveal (1) the relative amount of oil-prone vs. gas-prone organic matter in the source kerogen, (2) the age of the source rock, (3) the environment of deposition as marine, lacustrine, fluvio-deltaic or hypersaline, (4) the lithology of the source rock (carbonate vs. shale), and (5) the thermal maturity of the source rock during generation (e.g., Peters and Moldowan, 1993). Such data may be key inputs to delineate different Petroleum systems in a Sub Basin.

Nagapattinam sub-basin (**Fig. 1**) is located south of Karaikal ridge. It is a NE-SW trending basin bounded by the Mannargudi ridge on the south west, Karaikal ridge in the north and northeast and Tirutturaipundi – Vedaranniyam high comprises horsts and grabens trending in a NE-SW direction. Pallivaramngalam field is located on the south-western plunge of Karaikal High. Significant hydrocarbon discoveries are made within Lower/ Upper Kamalapuram, Bhuvanagiri and Andimadam formations. Most of the pools are stratigraphic closures as sand mound in cuts and fills, where sediments are deposited at the top of K/T unconformity surface. Hydrocarbon saturations are distributed vertically from Andimadam to Kamalapuram Formations (Albian to upper Eocene) in this area (Goswami.B.G., et al. 2006).

Fig.1: Location Map of Pallivaramangalam field , Nagapattinam Sub Basin, Cauvery Basin

In this paper, we have used Sterane and Triperpane distribution patterns for the correlation of Source Rock extracts from wells well-D, well-E & well-G and liquid hydrocarbons from the well-A, well-B, well-C, well-D, well-E, well-F well-G (Seifert & Moldowan, 1978, 1979; Volkman et al., 1983). Mainly two types of sterane distribution patterns have been seen in the Source rock extracts and the liquid hydrocarbons in this field.

"Type A", distribution in which the carbon number range is C_{27} to C_{29} and the predominant peaks are "normal" (5αH, 14αH, 17αH, 20R and S), "iso" (5αH, 14βH, 17βH, 20R and S) and "rearranged" steranes mainly (13βH, 17βH, 20R and S), (Seifert & Moldowan, 1978). The presence of C_{27} to C_{29} peaks are said to be derived from mixed algal, marine+ terrestrial, source rocks. The presence of rearranged steranes is characteristic of clay catalyzed rearrangement reactions whereby the precursor sterols are transformed, via unsaturated intermediates, to rearranged steranes (Rubinstein et al., 1975; Seiskind et al., 1979). The presence of rearranged steranes in a crude oil would therefore imply generation from a source rock containing clay minerals (shales, marls).

"Type B", distribution in which the steranes are predominantly, C_{29} compounds with "normal", "iso" and "rearranged" steriochemistries. Higher plants tend to preferentially synthesize sterols with C_{29} carbon atoms and many authors have related C_{29} sterol predominance in Source rock extracts and crude oils to the presence of land plant derived organic matter in the sediment.

Experimental

Saturated hydrocarbon fractions were isolated from the crude oils and the bitumens (from effective Source Rock(s)) by column chromatography over column of silica/ alumina using petroleum ether as an eluant. Saturated fractions of both liquid hydrocarbons and Source rock extracts were analysed in GC-MS. "Clarus 600" Mass Spectrometer, coupled with a Perkin Elmer "680GC". Analysis was carried out in both "whole scan" and "selective ion recording (SIR)" modes. The saturated fractions were injected at 290°C in the splitless mode. A DB-1MS capillary column (30m x 0.25mm x 0.25μ) was used for the saturate fraction. For the saturate fraction analysis, the oven temperature was programmed from 50°C (held 2 min) to 180°C at 10°C/min and to 300°C at 3°C/min, and then held at the final temperature for 25 min. GC eluants were fragmented by EI+ ionisation technique at 70 e.v.

The GC-MS interface and ion source were maintained at 275°C and 270°C, respectively during the experiment. The mass spectrometer was scanning from m/z 50-600, with a scan time of 1.0 s during the whole scan acquisition mode. Molecular geochemical parameters were calculated on the basis of comparative quantitative data from the gas and mass chromatograms of characteristic ions for different compounds.

Results

The analysis of Source rock extracts from three wells, well-D, well-E & well-G and liquid hydrocarbons from the wells well-A, well-B, well-C, well-D, well-E, well-F & well-G, has revealed the existence of two clear types of Source organic matter input in the Source rock extracts and the liquid hydrocarbons. The source rock extracts also show variation in the organic matter input from Oxfordian to Albian in well well-G

i)Source Rock extracts: The Sterane (m/z: 217) mass chromatogram of the Source rock extracts from well-D, well-E & well-G are shown in **Fig.2**. The Albian source extracts in all the three wells show "Type A" characteristics of steranes in which the carbon number range is C_{27} to C_{29} steranes and the "rearranged" steranes are present. The Hopanes (m/z: 191) chromatograms show the presence of

triterpanes Ts and Tm and the complete range of homohopanes from C_{31} to C_{35}. The mean value of C29/C30 17αH, 21αH hopane ratio is less than 1.

However the Sterane (m/z: 217) mass chromatogram of well-G from Oxfordian & older to Albian shows a change in characteristic from "Type B" in Oxfordian & older to "Type A" in Kimmeridigian & Albian. The Hopane mass chromatogram shows the significance presence of C_{30} diahopanes in the older source rock(s).

ii) Liquid hydrocarbons: The liquid hydrocarbons from well-A (Andimadam Fm), well-C (Andimadam Fm), well-E (Andimadam Fm) & well-G (Andimadam Fm) show "Type B" source characteristics, in which the steranes are predominantly, C_{29} compounds with "normal", "iso" and "rearranged" steriochemistries.

The liquid hydrocarbons from well-B (Andimadam Fm), well-D (Andimadam Fm & Kamalapuram Fm), well-E (Bhuvanagiri Fm) and   well-F (Nannilam Fm) show "Type A" characteristics of steranes in which the carbon number range is C_{27} to C_{29} steranes are present and the triterpane chromatogram shows the the presence of triterpanes Ts and Tm and the complete range of homohopanes from C_{31} to C_{35}. The mean value of C29/C30 17αH, 21αH hopane ratio is less than 1 **Fig.3.**

Discussion: The Albian Source rock extracts from, well-D, well-E & well-G show "**Type A"** characteristics of steranes in which the carbon number range is C_{27} to C_{29} steranes suggesting that the source organic matter input for these oils is mixed algal, marine + terrestrial.

However, in the well-G, there is a change in type facies from "**Type B"** in Oxfordian with dominance of C29 steranes indicating contribution from terrestrial source to "**Type A"** in Kimmeridigian and Albian with mixed algal+marine+ terrestrial. The C29/C30 17αH, 21αH hopane ratio is less than 1 indicating non carbonate origin of the source input in all the wells.

The liquid hydrocarbons from well-B (Andimadam Fm), well-D (Andimadam Fm & Kamalapuram Fm), well-E (Bhuvanagiri Fm) and well-F (Nannilam Fm) show "**Type A"** source characteristics, suggesting that the source organic matter input for these liquid hydrocarbons is mixed, algal, marine +terrestrial.

The source characteristics of the liquid hydrocarbons changes from Andimadam to Bhuvanagiri in the well-E, The liquid hydrocarbons from well-A (Andimadam Fm), well-C (Andimadam Fm), well-E (Andimadam Fm) & well-G (Andimadam Fm) show "**Type B"** source characteristics, suggesting that the source organic matter input for these oils is dominantly terrestrial, **Fig.4.**

Conclusion: Based on the sterane (m/z: 217) of the Source rock extracts and the liquid hydrocarbons there exist two type of petroleum systems in the Pallivaramangalam field.

 i) The **"Type A"** source facies signatures of wells-**D, E & G (Kimmeridigian & Albian**) are correlatable with the source input signatures of liquid hydrocarbons from well-**B, D, E (Bhuvanagiri) and F**, having mixed, algal, marine and terrestrial input. This indicates that these effective source rock(s), could have generated these oils

 ii)The **"Type B"** source facies signature of well-**G (Oxfordian & older)** is correlatable with the source input signatures of liquid hydrocarbons from well-**A, C, E (Andimadam) and G**, having dominantly terrestrial input. This indicates that these effective source rock(s) could have generated these oils.

iii) Oil to oil and oil to source correlation using Biomarker fingerprints in Pallivaramagalam field has helped in establishing two different kinds of petroleum systems; two different types of Source facies have generated these oils in Pallivaramnagalam field.

The wells show a vertical variation in source facies of the source rock extracts and the liquid hydrocarbons, indicating sea level changes, Transgression and Regression, which are responsible for the different type of source inputs over geological time frame from Oxfordian to Albian.

This study can be useful in Basin modeling studies of Ngapattinam Sub Basin and in reconstruction of the paleo depositional environment in the Sub Basin.
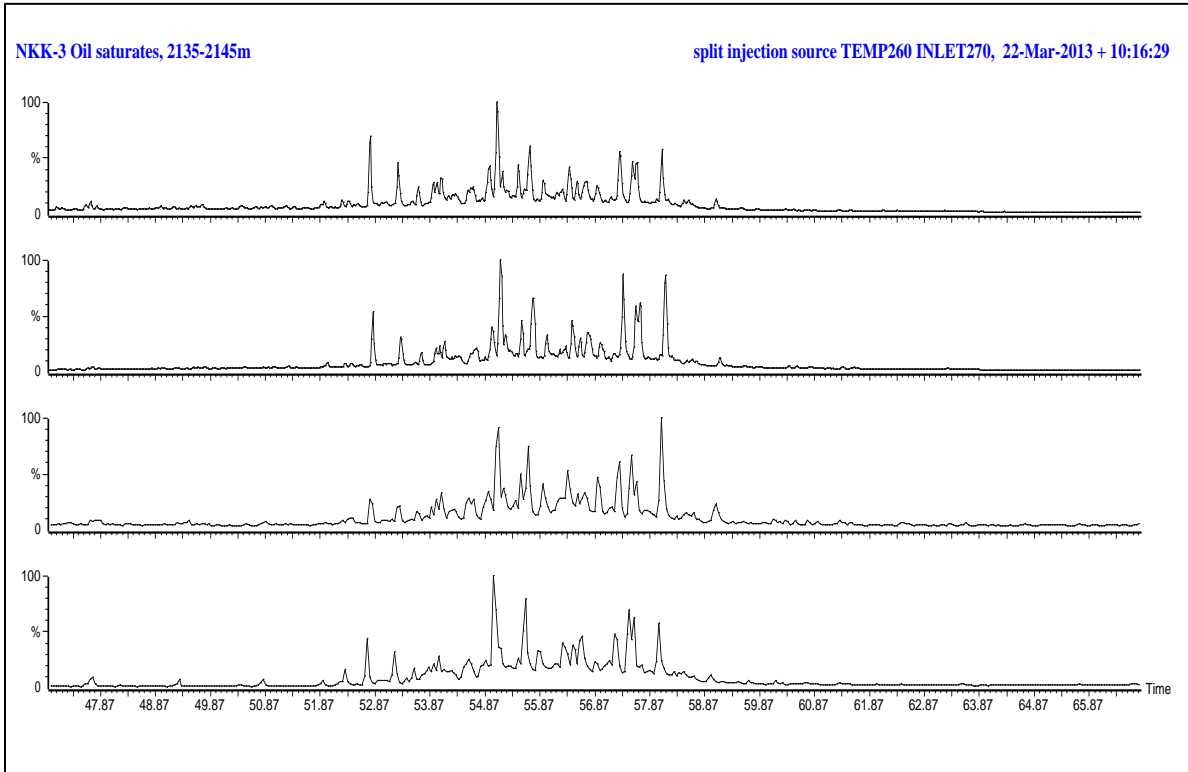
Fig.2: Sterane mass chromatogram showing variation in carbon number range C$_{27}$ to C$_{29}$ steranes of the source rock extracts. The C$_{27}$ & C$_{28}$ steranes are almost negligible in the older Oxfordian source rock(s)
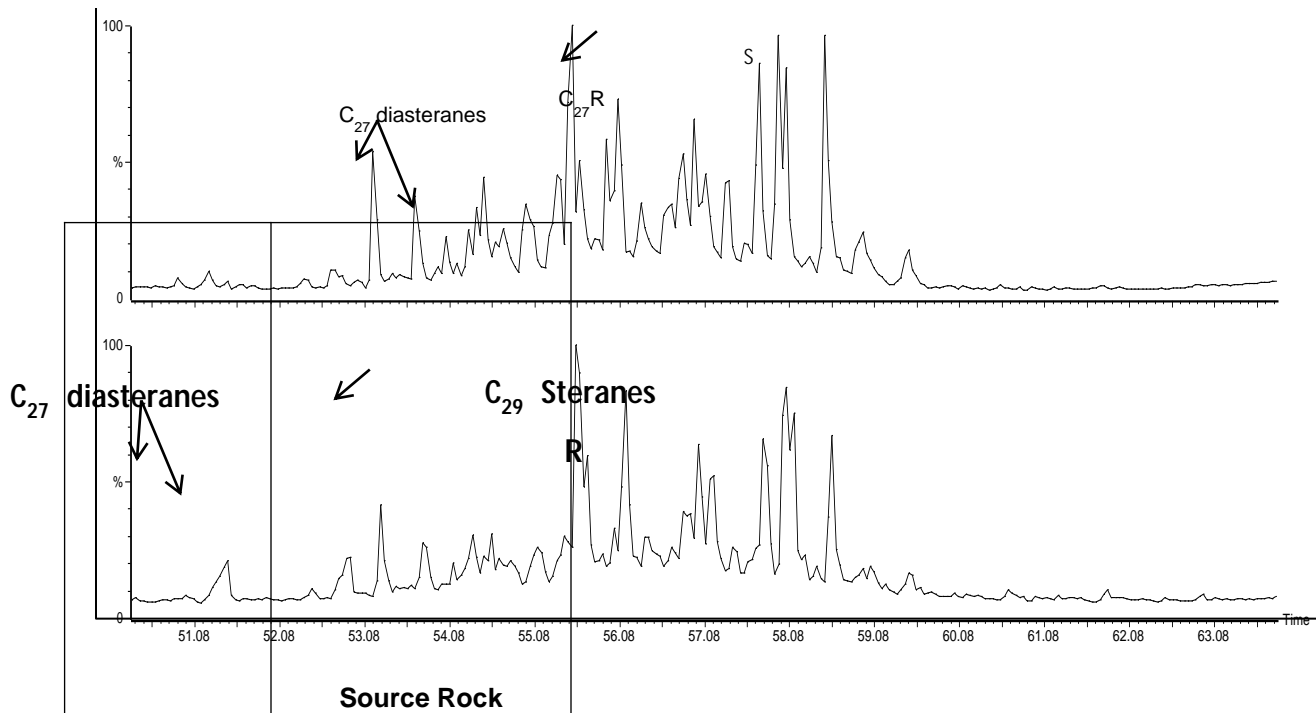

Fig.3: Sterane mass chromatogram showing variation in carbon number range C$_{27}$ to C$_{29}$ steranes of the liquid hydrocarbons. Two types of source input can be seen "Type A" & "Type B".

Source Rock Extracts Well name			
Age	Well D	Well E	Well G
Albian	Type A	Type A	Type A

Aptian			
Barremian			
Hautervian			
Valanginian			
Berriasian			
Tithonian			
Kimmeridigian			Type A
Oxfordian & Older			Type B

Formation	Liquid hydrocarbons Depth/ Object Well name						
	Well A	Well B	Well C	Well D	Well E	Well F	Well G
Tirupundi							
Karaikal				Type A			
Neravy							
Kamalapuram							
Nannilam				Type A		Type A	
Bhuvanagiri					Type A		
Andimadam	Type B	Type A	Type B	Type A	Type B		Type B

◼ Source OM input Dominantly terrestrial

◼ Source OM input mixed algal, marine+terrestrial

Fig.4. Correlation between the source organic matter input of the source rock extracts and the liquid hydrocarbons in PM field.

Acknowledgement:

References:

Peters, K.E., Moldovwan, J.M., 1993. The Biomarker guide: Interpreting Molecular fossils in Petroleum and Ancient sediments. Prentice-Hall, Englewood Cliffs, NJ.

Goswami, B.G., Bisht, R.S., Mittal,A.K.,2006. Genetic relationship between the crude oils and source rocks in the Nagapattinam Sub-Basin, Cauvery Basin,Through Biomarker studies and other non-biomarker parameters.

Seifert W.K.and Moldowan J.M.,1978. Applications of steranes, terpanes and monoaromatics to the maturation, migration and source of crude oils. Geochim. Cosmochim Acta 42, 77-95.

Volkman J.K., Alexander R., Kagi R I., Noble R.A. and Woodhouse G.W. 1983. A geochemical reconstruction of oil generation in the Barrow Sub-basin of Western Australia. Geochim. Cosmochim Acta 42, 2091-2105.

Rubinstein I., Sieskind O. and Albrecht P.,1975., Rearranged steranes in a shale, occurrence and simulated formation. J. Chem. Soc. Perkin Trans. 1833-1836.

Sieskind O., Joly G. and Albrecht P. 1979. Simulation of the geochemical transformations of sterols; superacid effect of clay minerals. Geochim. Cosmochim Acta 43, 1675-1679.