Organic Geochemistry 76 (2014) 9–25

Contents lists available at ScienceDirect

Organic Geochemistry

journal homepage: www.elsevier.com/locate/orggeochem

Tertiary oils from Upper Assam Basin, India: A geochemical study using terrigenous biomarkers

Neeraj Mathur *

Centre of Excellence for Energy Studies, Oil India Limited, Rukminigaon, G S Road, Guwahati 781 022, Assam, India

ARTICLE INFO

Article history:
Received 20 October 2013
Received in revised form 9 June 2014
Accepted 14 July 2014
Available online 26 July 2014

Keywords:
Upper Assam Basin
Tertiary oils
Terrigenous biomarkers
Rearranged oleananes
Bicadinanes

ABSTRACT

The Upper Assam Basin in northeast India is a Tertiary sub-basin of the Assam-Arakan Basin. Hydrocarbons are present in the Langpar Formation (Upper Palaeocene), Lakadong member of the Sylhet Formation (Lower Eocene), and the Barail (Oligocene), Tipam (Lower Miocene) and Girujan (Middle Miocene) formations in the basin. A detailed study to understand the nature and origin of the oils from different stratigraphic horizons using terrigenous and other biomarkers has been carried out. Further, the variation in maturities of oils occurring in different stratigraphic horizons has also been studied. The study shows that rearranged oleananes, oleananes and bicadinanes are present in these oils implying land plant input to their source rocks. The oils have been classified into different groups, using ratios of rearranged oleananes, oleananes, bicadinanes and steranes, indicating presence of multiple source rocks in the basin with subtle variation in characteristics. Maturity studies show that oils from younger horizons (Barail, Tipam and Girujan) are more mature than oils from older horizons (Langpar and Lakadong). There is an apparent mismatch in maturity of oils as measured by different biomarker maturity parameters. This is due to the mixing of two different charges of oils, having different maturities and generated from two different source rock kitchens, in the same reservoir. Principal component analysis (PCA) of biomarker data has also been able to classify the oils into various groups. A new parameter has been developed, using ratios of rearranged oleananes, for determining maturity of these oils.

1. Introduction

The Upper Assam Basin is a Tertiary sub-basin of the Assam-Arakan geological province located in the northeastern part of the Indian subcontinent (Fig. 1). It has been a prolific hydrocarbon producer for more than a century since oil was first discovered in Digboi in Upper Assam in 1889. The Digboi oilfield is still producing from the Tipam Formation (Lower Miocene), although at a very low rate. Hydrocarbons were discovered in the Oligocene Barail Formation (1950s) followed by Upper Miocene Girujan Formation (1970s). More recently, in 1989, hydrocarbons were also discovered in deeper reservoirs in the Lakadong member of the Sylhet Formation (Lower Eocene) and the Langpar Formation (Upper Palaeocene).

Mathur et al. (2000) studied oils from Lakadong and Langpar reservoirs from the Upper Assam Basin, using whole oil gas chromatography. Their study has shown that these oils are waxy with a predominance of *n*-alkanes in the carbon number range of 21–35 with maxima at C_{29}. Moreover, pristane/phytane for these oils is > 3. Thus, Lakadong and Langpar oils in the Upper Assam Basin are derived from terrigenous organic matter (Hedberg, 1968; Tissot and Welte, 1984).

Mathur and Das (2013) carried out a study on the origin and maturity of Lakadong and Langpar oils in the basin using selected ion monitoring GC–MS analysis of biomarkers. They showed that these oils have high oleanane and low sterane contents. Further, C_{29} steranes are predominant amongst C_{27}, C_{28} and C_{29} steranes. The oils are derived from terrigenous source rocks deposited under oxic to sub-oxic conditions. Also, the oils are early to mid-mature and show evidence of migration contamination (Curiale and Bromley, 1996).

An oil to source rock correlation study by Goswami et al. (2005) in the western part of the basin showed that oils from the Bokabil (Early to Middle Miocene) and Sylhet (Middle to Late Eocene) formations are derived from terrigenous organic matter. The oils have significant amounts of oleananes and bicadinanes, confirming their terrigenous origin (Ekweozor and Udo, 1988; Alam and Pearson, 1990; Ekweozor and Telnaes, 1990; van Aarssen et al., 1990, 1992a; Curiale et al., 1994; Murray et al., 1994; Nytoft et al., 2010).

Several higher plant related C_{30} triterpanes have been observed in Late Cretaceous/Tertiary oils from Southeast Asia, New Zealand

* Tel.: +91 9435039751; fax: +91 361 2262555.
E-mail addresses: nmathur@oilindia.in, neeraj.nmathur@gmail.com

http://dx.doi.org/10.1016/j.orggeochem.2014.07.007
0146-6380/

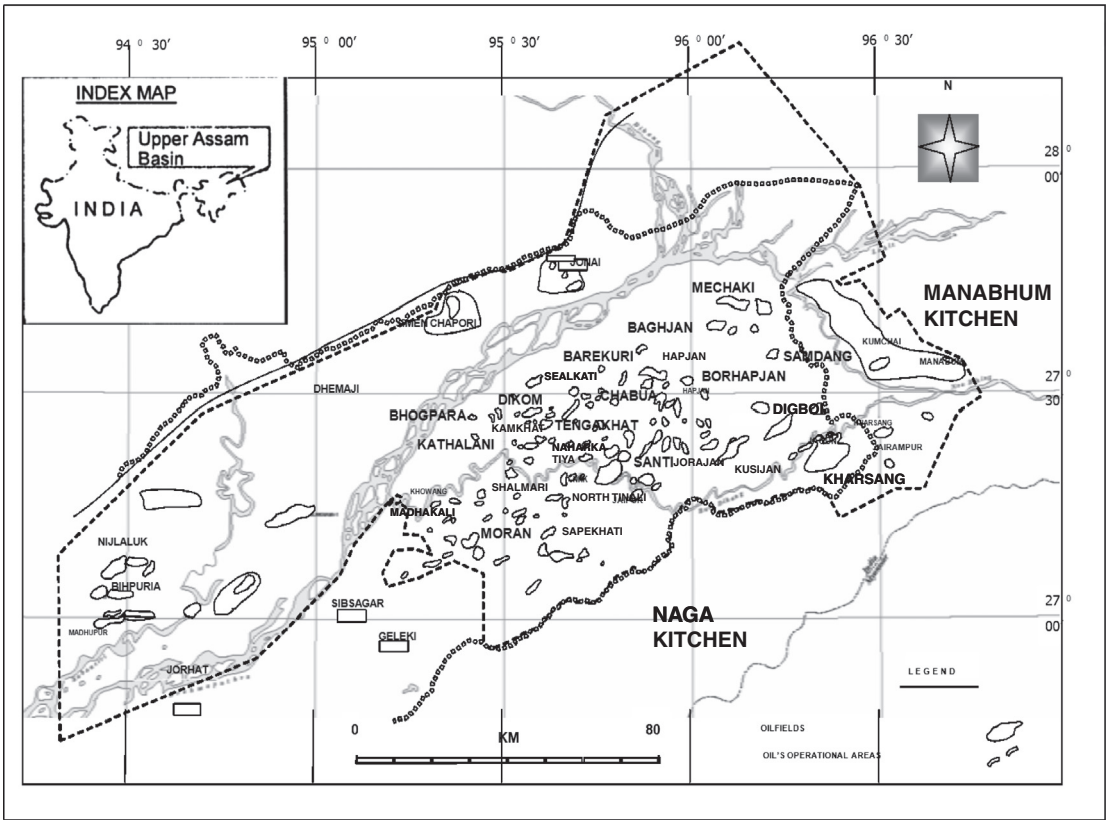

Fig. 1. Map of the study area showing location of oilfields.

and Nigeria (Ekweozor et al., 1979a,b; Ekweozor and Udo, 1988; Curiale and Lin, 1991; van Aarssen et al., 1992a; Woodhouse et al., 1992; Murray et al., 1994; Sosrowidjojo et al., 1994). Detection of these compounds in oils and sediments requires a higher selectivity method like metastable reaction monitoring (MRM) GC–MS (Murray et al., 1994; Nytoft et al., 2010).

In this paper, oils from Girujan, Tipam, Barail, Lakadong and Langpar reservoirs from the Upper Assam Basin have been studied using MRM GC–MS, for the analysis of biomarkers such as C_{30} triterpanes, oleananes, bicadinanes, hopanes and steranes, to understand their origin and maturity and to group them into different families. Further, a ratio using C_{30} triterpanes (rearranged oleananes) has been developed as a maturity parameter for these oils.

2. Geological setting

The Upper Assam Basin is bounded in the northwest by the eastern Himalayas, in the south by the Naga-Patkai Hills, in the northeast by the Mishmi Hills and in the southwest by the Mikir Hills and Shillong Plateau. The basin came into existence during the Cretaceous and Early Cenozoic period and was located in a passive continental margin facing an open sea. The Upper Assam Basin had received clastic sediments in varied shallow marine to paralic and non-marine (deltaic, fluviatile) environmental conditions in different geological times during Tertiary period. In the present day configuration of the basin, the basement dips both towards the southeast and northwest on the southern and northern flanks of the basement ridge, respectively. The basement ridge which trends NE–SW is possibly the eastern continuation of the Mikir Hills and runs almost parallel to the present day Brahmaputra River. The sedimentary thickness, which is < 4 km along the axis of the basement ridge, increases to > 7 km towards the Naga-Patkai range and the eastern Himalayan foothills region. The generalised stratigraphic succession of the Upper Assam Shelf along with the petroleum system is shown in Fig. 2 (Raju and Mathur, 1995; Mathur et al., 2001).

3. Experimental

3.1. Samples

Thirty-seven well head crude oil samples were collected from wells producing from Girujan, Tipam, Barail, Lakadong and Langpar reservoirs in Upper Assam Basin (Table 1) ensuring coverage of geographically dispersed oilfields. All the analyses were carried out in the laboratory of Oil India Limited operating under ISO17025 standard.

3.2. Separation

Asphaltenes were precipitated from oils by adding 50 times excess *n*-hexane. The precipitated asphaltenes were Soxhlet extracted to remove any trapped hexane soluble fraction. The hexane soluble fraction was added to the maltenes obtained above. Maltenes were separated into saturated hydrocarbons, aromatic hydrocarbons and resins fraction using the Radke et al. (1980) medium pressure liquid chromatography method. *n*-Alkanes were removed from the saturated hydrocarbon fraction using Geokleen (GH Geochem, UK). The resulting fraction, enriched in biomarkers, was subjected to MRM GC–MS analysis.

3.3. GC–MS analysis

MRM GC–MS analysis was carried out using ThermoFisher Trace Ultra gas chromatograph connected to TSQ triple stage