Petroleum Generation Kinetics and its Outcome in Basin Modeling of Upper Assam Shelf, India*

Sukumar Pahari[1]

Search and Discovery Article #10314 (2011)
Posted April 25, 2011

*Adapted from extended abstract presented at GEO-India, Greater Noida, New Delhi, India, January 12-14, 2011.

[1](skumar_pahari@rediff.com)

Abstract

The focus of oil exploration and development of oil fields has been mainly on the foreland and shelf edge part of Upper Assam, a southeast dipping shelf over thrust by the Naga Hills. Source and accumulation histories of these oils assume significance in prioritizing the future exploration efforts. Available data on conventional maturity parameters like vitrinite reflectance (VRo), Rock Eval Tmax and Production Index (PI) values fail to indicate the existence of effective source rocks, which could have expelled towards existing hydrocarbon pools within the foreland and shelf edge part of Upper
Assam Shelf.

Basin modeling incorporates the simulation of basin geometry to assess charge risk associated with each of the various elements of the petroleum system by integrating diverse geological, engineering, and geochemical data including custom kerogen kinetics. Data has been used along dip section within the foreland and shelf edge part of Upper Assam to assess effect of petroleum generation kinetics on hydrocarbon generation and for evaluation of possible hydrocarbon contribution from the foreland and shelf edge part of Upper Assam Shelf towards existing hydrocarbon pools.

Heat Flow Calibration

Numerical simulations of the burial, temperature and maturity history of source rocks are performed using a 1-D model at various well locations. The 1D model includes burial histories and thermal modeling which was calibrated taking into account the subsurface reservoir temperature wherever available otherwise stable bottom hole temperature and maturity data e.g. Vitrinite reflectance (VRo)

were taken. The end-results of 1-D simulations show that heat flow values at various modeled locations are not same. Calibrated heat flow values at various locations SNRI, LKW, KG, NRDS, CRLI, CKMK, BHBR, GLKI, RJP are 45, 45, 40, 45, 40, 39, 45, 45, 45 mW/m^2 respectively.

Input Data

In 2-D modeling, the 21.6 km long MK- SNRI section (a-a' in Figure 1) in north Assam and the 21.9 km long RJP section (b-b' in Figure 1) in south Assam were modeled in order to investigate the possibility of generation/expulsion of hydrocarbons from Barail and Kopili source rocks and Kopili source rocks respectively. Each formation/layer is assigned with its pertinent lithology and facies (Table 1 and Table 2). Input heat flow values that vary along a section are assigned according to 1D model heat flow calibration data at different locations. The basal heat flow of $45mW/m^2$ is used in both the MK- SNRI and RJP sections. The kerogen-hydrocarbon kinetics used in the model are based upon laboratory measured kinetic parameters of immature Kopili and in Barail source rocks where principal activation energy range is between 52-56kcal/mol and 50-54Kcal/mol respectively (Figure 2). The lateral variation in the facies from area to area, within individual layer is also taken into account. Three laterally varied different source facies i.e. one at MK-KG area, second at LKW area, third at SNRI area for each Kopili, BMS and BCS source rocks are used for simulation of the MK- SNRI section (Figure 3). Information available on basin geometry, age, erosion, fault, custom lithology, stratigraphy with petroleum system element, paleo-water depth and source rock data (TOC, kerogen kinetics, HI) was used as input data for the conceptual model of the basin. The sediment-water interface temperatures are based on Wygrala (1989).

Results of Modeling Using Kinetic Data and Conclusions

Results of modeling for the MK-SNRI section in the shelf part of north Assam reveals that all source rocks in the shelf part are immature at 10Ma. The bottom part of the Kopili section is early mature at 6 Ma but top part of Kopili source rocks, BMS source rocks and bottom of BCS source rocks attain early maturity at present day (Figure 4 and Figure 5). Bottom part of Kopili is peak mature at present day. Upper BCS source rocks are still immature at present day. Kerogen transformation of Kopili, BMS, and BCS source rocks has reached a maximum of 14.13%, 8.56% and 2.11% respectively at present day (Figure 6). Generated mass of bulk hydrocarbon from Kopili and BMS source rocks has reached a maximum of 6,000 tons and 9,194 tons respectively but expulsion mass bulk 0.001 $Mtons/km^2$ and 0.0001 $Mtons/km^2$ at present day. Kerogen transformation of Kopili, BMS, and BCS source rocks has reached a maximum of 10.34%, 5.38% and 1.19% respectively at 1.8 Ma (Figure 7). Volumetrics of hydrocarbon generation, expulsion, accumulation for MK-SNRI section shows that out of about 0.72MMT of expelled hydrocarbons, only about 0.32MMT has been accumulated in the reservoir (Table 3).

Results of modeling for the RJP section in the shelf part of south Assam reveals that the whole RJP section is immature at 1.8Ma but Kopili source rocks attain early maturity at present day (Figure 8) towards the east (Dimapur low). Kerogen transformation of Kopili source rocks has reached a maximum of 2.5% at the eastern low at present day (Figure 9). Generated mass of bulk hydrocarbon has reached a maximum of 4,455 tons and expulsion mass bulk 3,444.7 tons maximum at the eastern most side of this section. Volumetrics of hydrocarbon generation, expulsion, accumulation for RJP section shows that out of about 0.12MMT of expelled hydrocarbons, only about 0.11MMT has been accumulated in reservoir (Table 3). Simulation with default IFP Type-III petroleum generation kinetics shows no significant kerogen transformation of source rocks from MK-SNRI section in the north Assam and the RJP section in south Assam within the foreland and shelf edge part of Upper Assam Shelf. But the simulation for these sections with custom petroleum generation kinetics for Barail and Kopili source rocks reflect the possibility of the occurrence of some gaseous and liquid hydrocarbon that could be trapped against the structural highs within the foreland and shelf edge part of Upper Assam Shelf from Dimapur low and Nazira low and adjoining areas i.e. LKW-SNRI, GLKI.

References

Wygrala B., 1989, Integrated study of an oil field in the southern Po basin, northern Italy: Berichte kernforschungsamlage, Julich, 2313, p.217

Acknowledgements

The authors acknowledge ONGC management for permission to publish this work. The authors are highly indebted to Shri P. K. Bhowmick, ED-HOI, KDMIPE for his constant guidance and keen interest in this work.

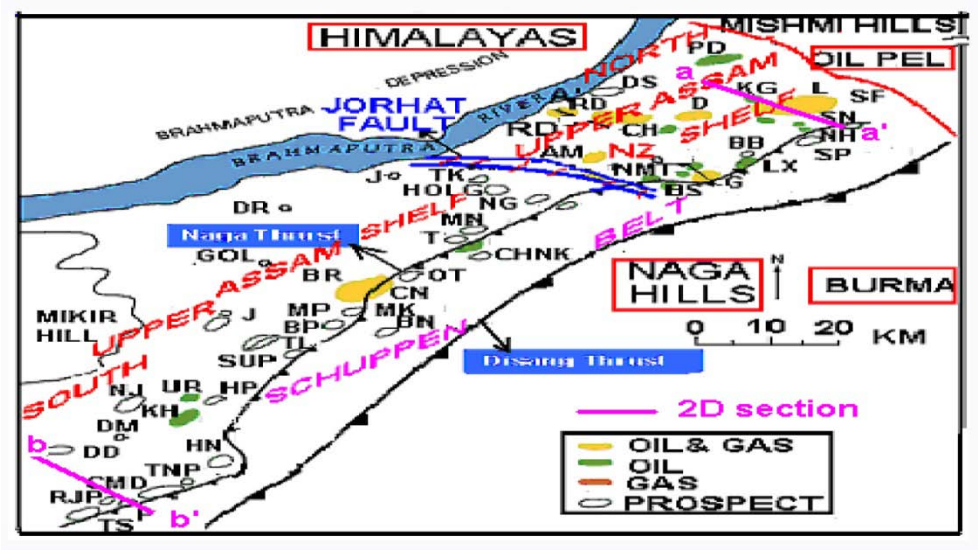

Figure 1. Location map of Upper Assam Shelf showing modeled 2-D sections.

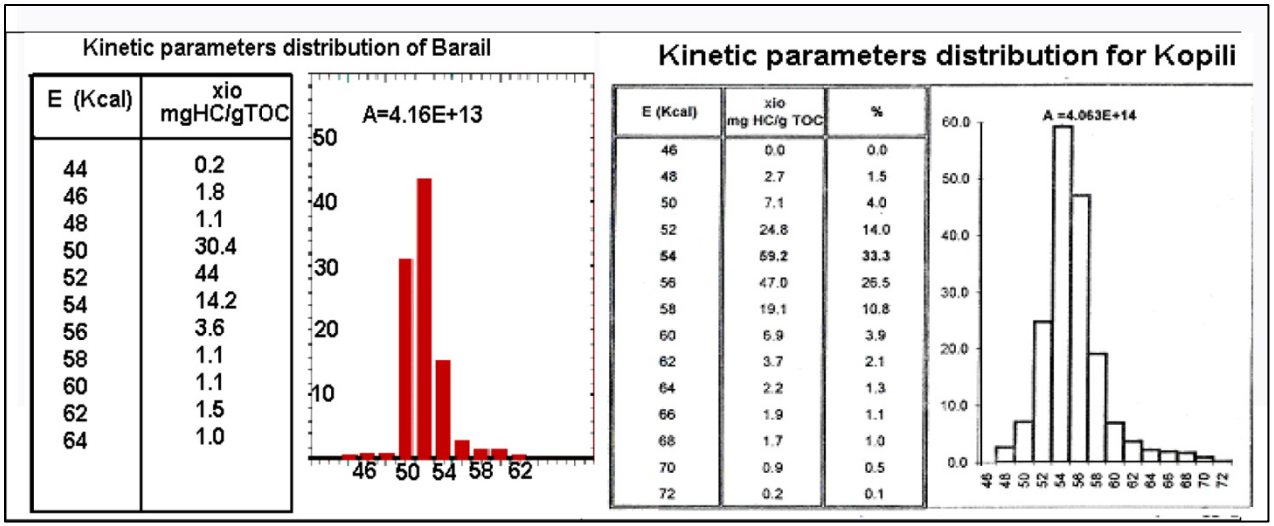

Figure 2. Petroleum generation kinetics of Upper Assam Shelf.

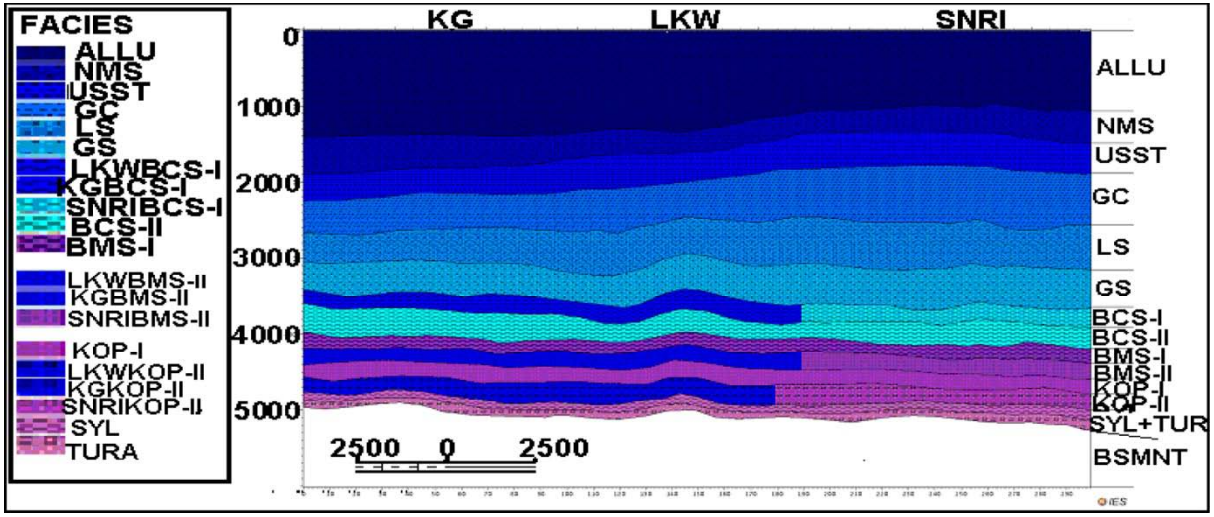

Figure 3. Facies map of modeled MK-SNRI section.

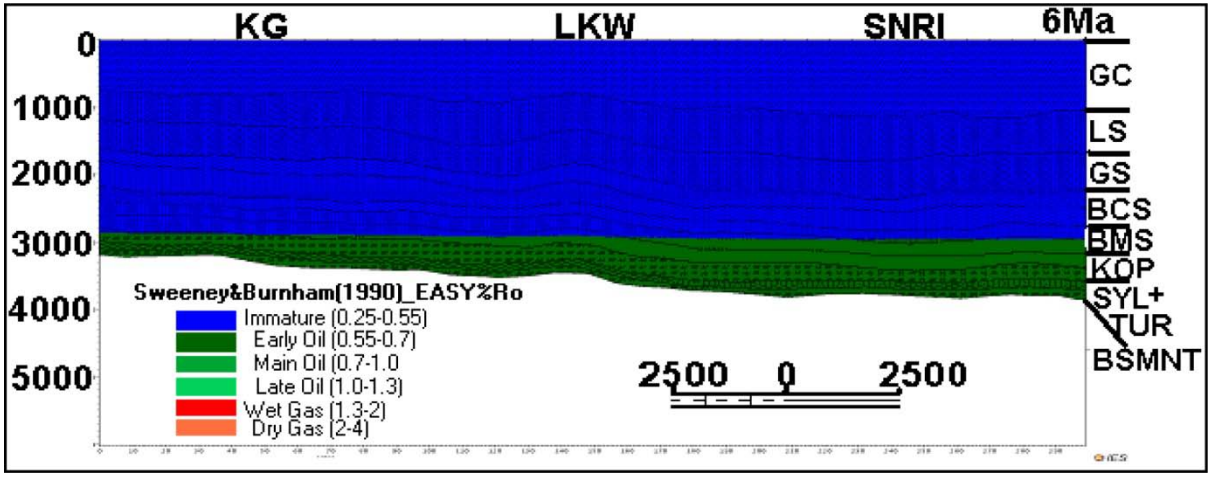

Figure 4. Oil window maturity of source rocks in modeled MK-SNRI section at 6 Ma.

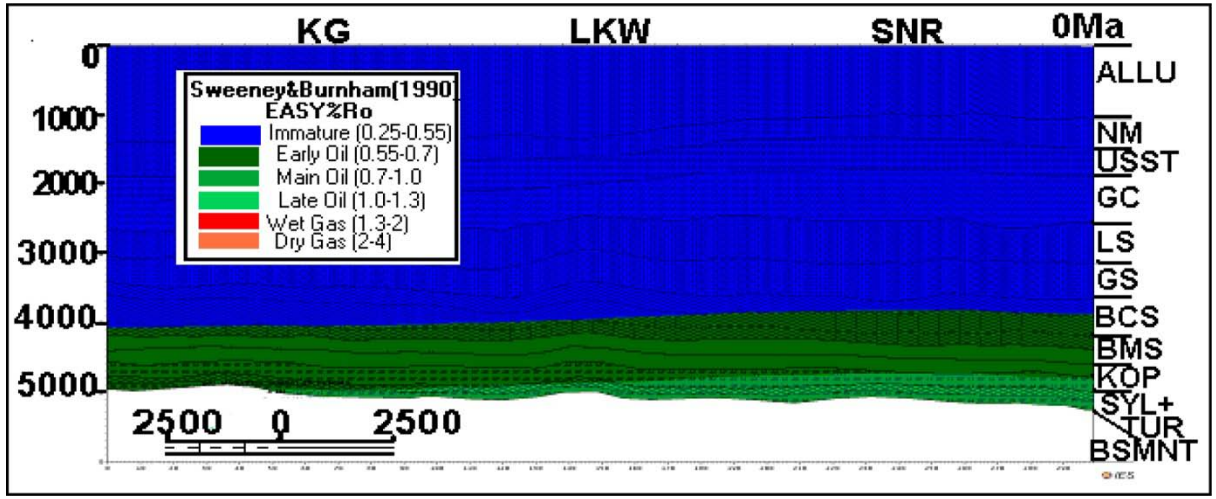

Figure 5. Oil window maturity of source rocks in modeled MK-SNRI section at 0 Ma.

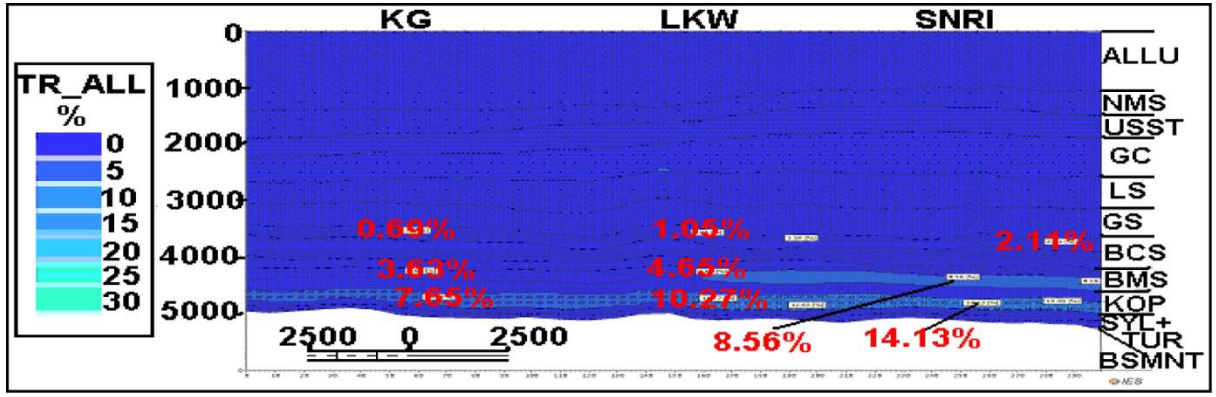

Figure 6. Kerogen transformation of source rocks in modeled MK-SNRI section at 0 Ma.

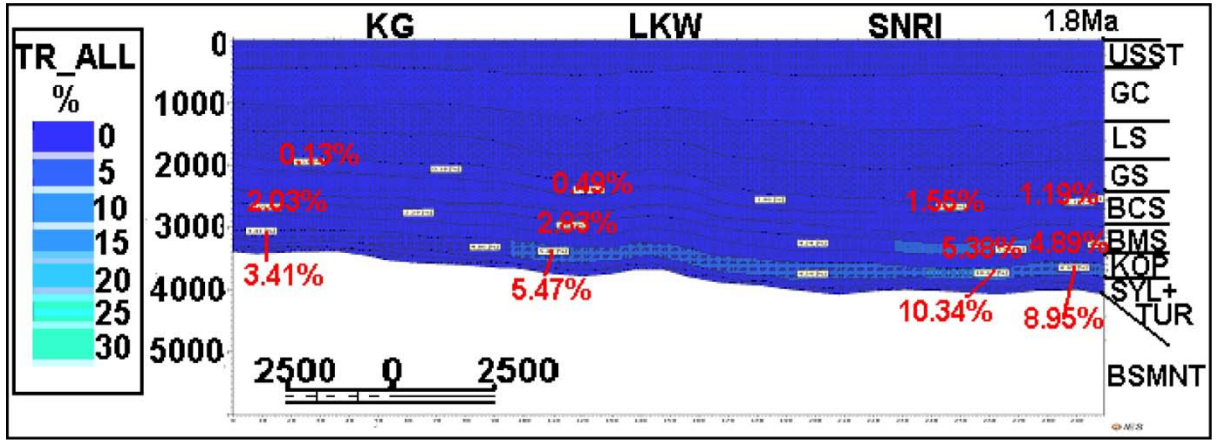

Figure 7. Kerogen transformation of source rocks in modeled MK-SNRI section at 1.8 Ma.

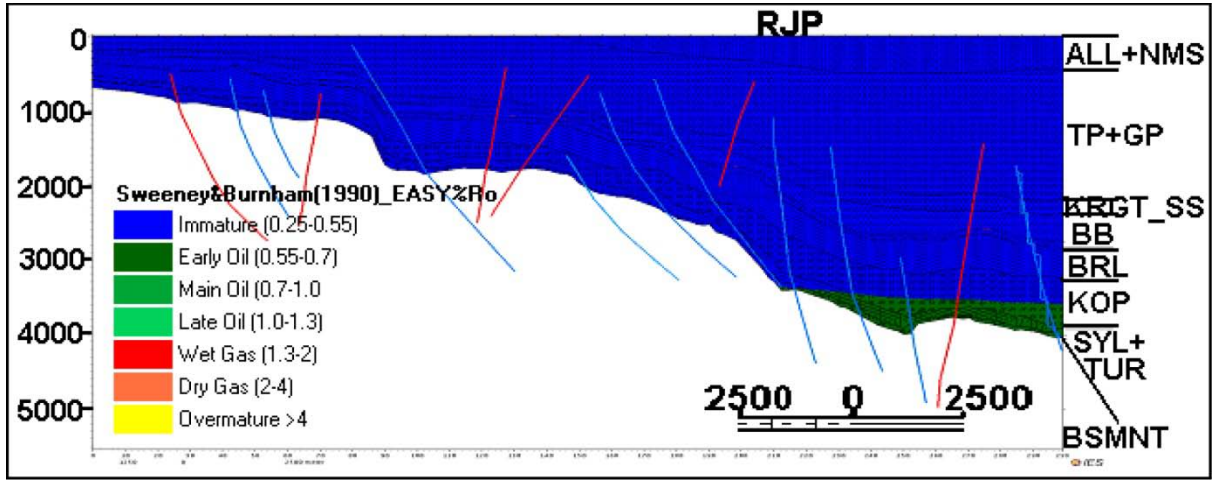

Figure 8. Oil window maturity of source rocks in modeled RJP section at present day.

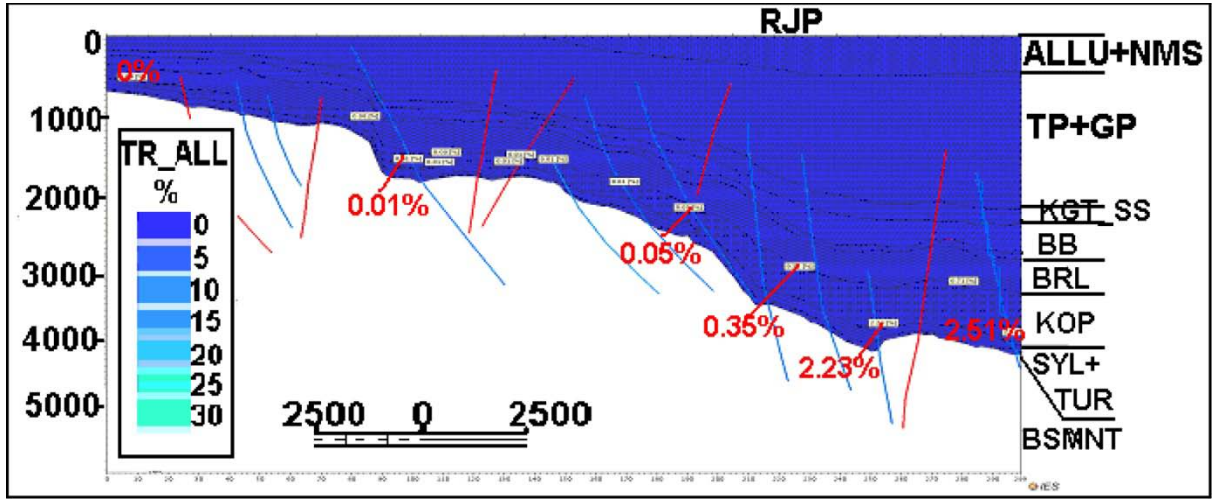

Figure 9. Kerogen transformation of source rocks in modeled RJP section at present day.

Facies name	Petroleum system	Lithology	TOC	Kinetics	HI
ALLU	Overburden Rock	Sandstone (subarkose, clay rich)	0	none	0
NM	Overburden Rock	Sandstone (subarkose, clay poor)	0	none	0
USST	Overburden Rock	Sandstone (arkose, quartz rich)	0	none	0
GC	Seal Rock	Shale (typical)	0	none	0
LS	Reservoir Rock	Sandstone (typical)	0	none	0
GS	Reservoir Rock	Sandstone (typical)	0	none	0
Sonari_BCS-I	Source Rock	BCS-I-S	26.4	Barail_g172	196
Sonari_BCS-II	Reservoir Rock	BCS-II-R	0	none	0
Sonari_BMS-I	Reservoir Rock	BMS-I-R	0	none	0
Sonari_BMS-II	Source Rock	BMS-II-S	4	Barail_g172	150
Sonari_KOP-I	Reservoir Rock	KOPILI-I-R	0	none	0
Sonari_KOP-II	Source Rock	KOPILI-II-S	3	Kopili_g158	100
SYL	Reservoir Rock	SYLHET	0	none	0
TUR	Reservoir Rock	TURA	0	none	0
BSMNT	Underburden Rock	Gneiss	0	none	0
KG4_BCS	Source Rock	BCS-I-S	30.3	Barail_g172	231
KG4_BMS	Source Rock	BMS-II-S	21.2	Barail_g172	205
KG4_KOP	Source Rock	KOPILI-II-S	1	Kopili_g158	96
LKW_BCS	Source Rock	BCS-I-S	41.7	Barail_g172	189
LKW_BMS	Source Rock	BMS-II-S	5.2	Barail_g172	142
LKW_KOP	Source Rock	KOPILI-II-S	1.3	Kopili_g158	97

Table1. Assigned facies characteristics of MK-SNRI section.

Facies name	Petroleum system	Lithology	TOC	Kinetics	HI
ALLU_NM	Overburden Rock	Sandstone (subarkose, clay rich)	0	none	0
TP-GP	Overburden Rock	Sandstone (arkose, quartz rich)	0	none	0
KGT_SS	Overburden Rock	Sandstone (arkose, typical)	0	none	0
MID_BB	Seal Rock	Shale (typical)	0	none	0
LR_BB	Reservoir Rock	Sandstone (typical)	0	none	0
BRL	Reservoir Rock	BMS-I-R	0	none	0
KOP	Source Rock	KOPILI-II-S	1.2	Kopili_g158	158
SYL	Reservoir Rock	SYLHET	0	none	0
TUR	Reservoir Rock	TURA	0	none	0
BSMNT	Underburden Rock	Gneiss	0	none	0

Table 2. Assigned facies characteristics of RJP section.

MK-SNRI section	Gas+Oil	RJP section	Gas+Oil
BCS-I	0.01693	-	-
BMS-II	0.3119	-	-
KOP-II	0.547601	-	-
Sum Generated	0.868911	KOP	0.149888
BCS-I	0.0168586	Sum Generated	0.149888
BMS-II	0.000251524	-	-
KOP-II	0.128773	KOP	0.0266282
Sum Accumulated in Source	0.145884	Sum Accumulated in Source	0.0266282
BCS-I	7.14E-05	-	-
BMS-II	0.31176	-	-
KOP-II	0.418828	KOP	0.12326
Sum Expelled	0.723028	Sum Expelled	0.12326
LS	0.320398	LR_BB	0.1118
Sum Accumulated in Reservoir	0.320398	Sum Accumulated in Reservoir	0.1118
Migration Losses	0.0267198	Migration Losses	2.81E-09
Sec. Cracking Losses	0.304267	Sec. Cracking Losses	0.00174666
Sum Outflow Top Losses	4.10E-06	Sum Outflow Top	0.00963227
Sum Outflow Side Losses	0.0716386	Sum Outflow Side	8.06E-05
Sum HC Losses	0.40263	Sum HC Losses	0.0114595

Table 3. Volumetrics of modeled section of Upper Assam Shelf.