641 / 597 Mr. Sukumar Pahari

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

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 T_{max} 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 which incorporates the simulation of basin geometry to assess charge risk associated with each of the various elements of 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 simulation of the burial, temperature and maturity history of source rocks is performed using 1-D model at various well locations. The 1D model includes burial histories and thermal modeling which was calibrated taking into account of 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 modelled 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, 21.6 km long MK- SNRI section (a-a' in Figure-1) in north Assam and 21.9 km long RJP section (b-b' in Figure-1) in south Assam was 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 are used in both MK- SNRI and RJP section. The kerogen-hydrocarbon kinetics used in the model is 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 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 MK-SNRI section in shelf part of north Assam reveals that all source rocks in shelf part are immature at 10Ma. The bottom part of 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 is maximum up to 14.13%, 8.56% and 2.11% respectively at present day (Figure-6). Generated mass of bulk hydrocarbon from Kopili and BMS source rocks is maximum up to 6000 tons and 9194 tons respectively but expulsion mass bulk 0.001 Mtons/sq.km and 0.0001 Mtons/sq.km. at present day. Kerogen transformation of Kopili, BMS, and BCS source rocks is maximum up to 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 reservoir (Table-3).

Results of modeling for RJP section in 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 east (Dimapur low). Kerogen transformation of Kopili source rocks is maximum up to 2.5% at eastern low at present day (Figure-9). Generated mass of bulk hydrocarbon is maximum up to 4455 tons and expulsion mass bulk 3444.7 tons maximum at 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 north Assam and 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

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Tables and Figures

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

Table-1: 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

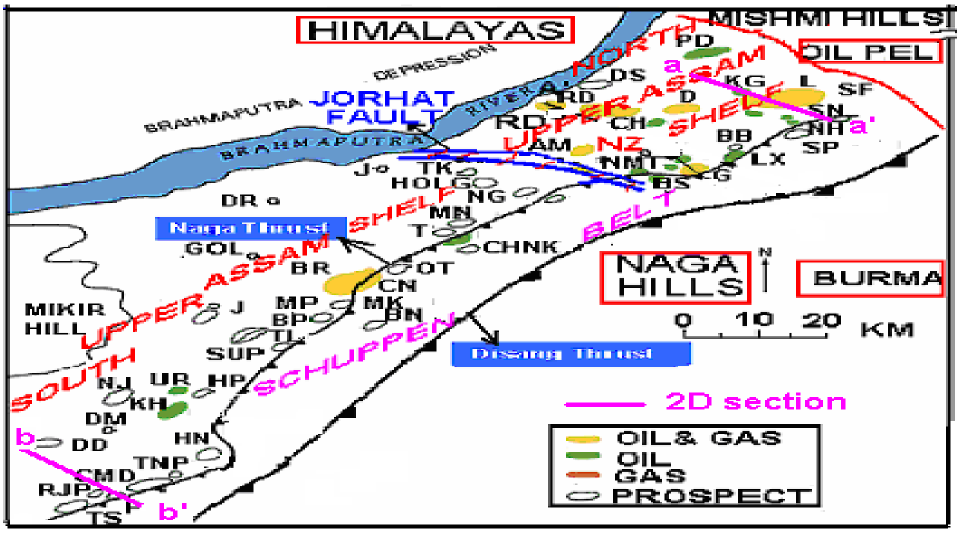
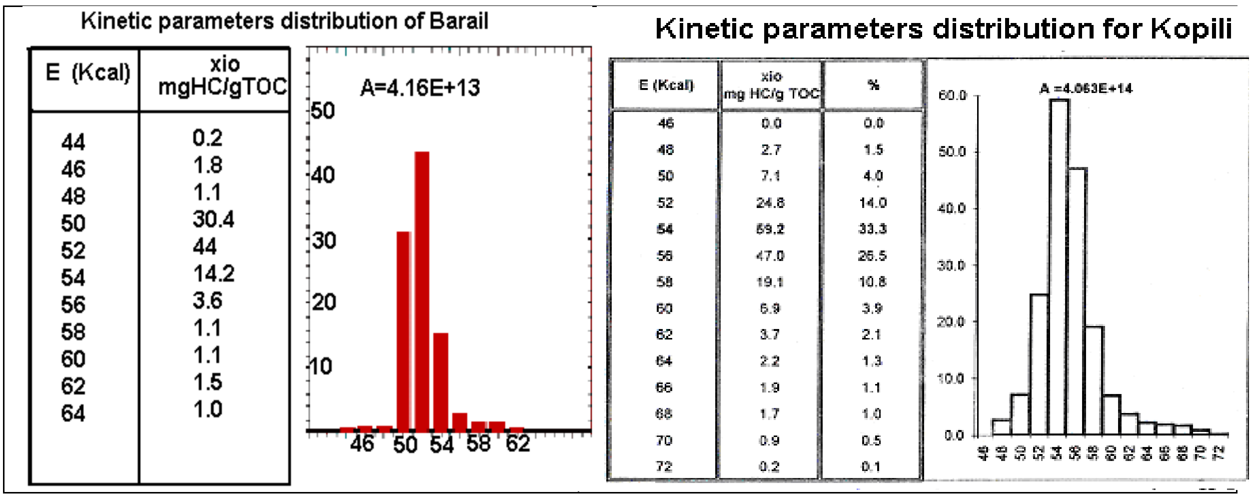


Figure-1: Location map of Upper Assam Shelf showing modeled 2-D sections



Kinetic parameters distribution of Barail

E (Kcal)	xio mgHC/gTOC
44	0.2
46	1.8
48	1.1
50	30.4
52	44
54	14.2
56	3.6
58	1.1
60	1.1
62	1.5
64	1.0

Kinetic parameters distribution for Kopili

E (Kcal)	xio mg HC/g TOC	%
46	0.0	0.0
48	2.7	1.5
50	7.1	4.0
52	24.8	14.0
54	59.2	33.3
56	47.0	26.5
58	19.1	10.8
60	6.9	3.9
62	3.7	2.1
64	2.2	1.3
66	1.9	1.1
68	1.7	1.0
70	0.9	0.5
72	0.2	0.1

Figure-2: Petroleum generation kinetics of Upper Assam Shelf

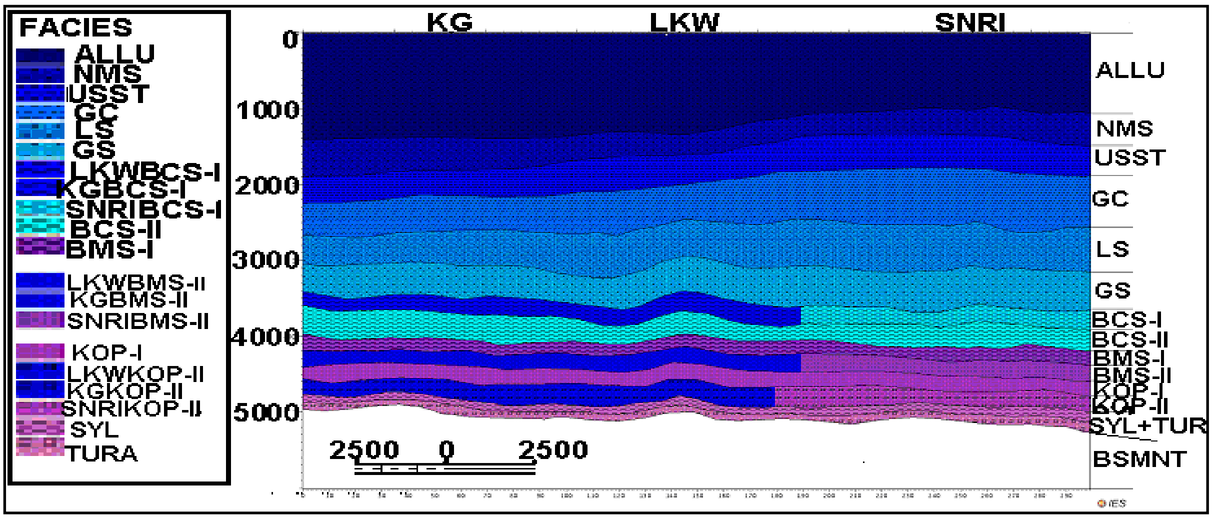


Figure-3: Facies map of modeled MK-SNRI section

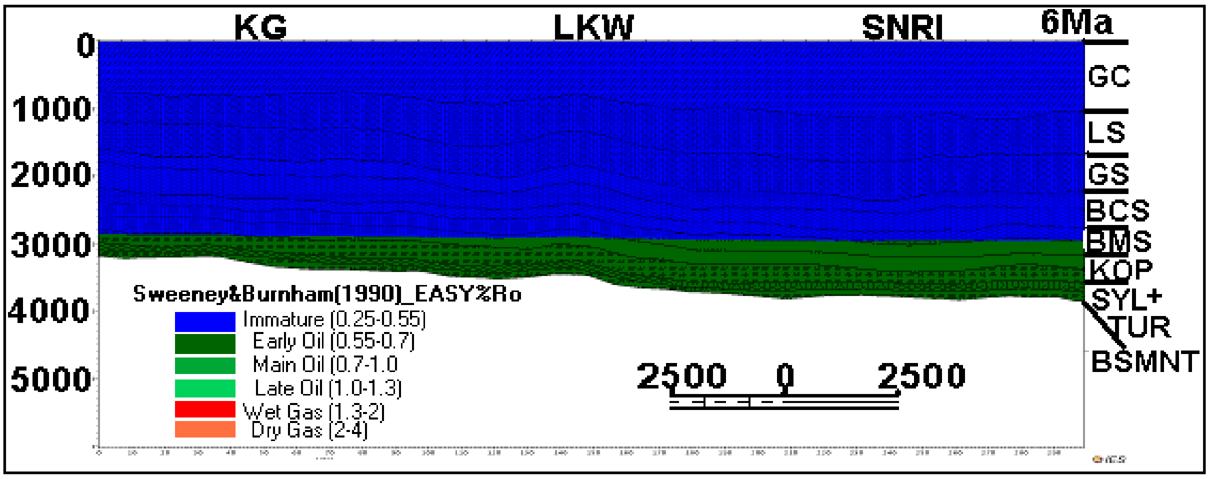


Figure-4: Oil window maturity of source rocks in modeled MK-SNRI section at 6Ma

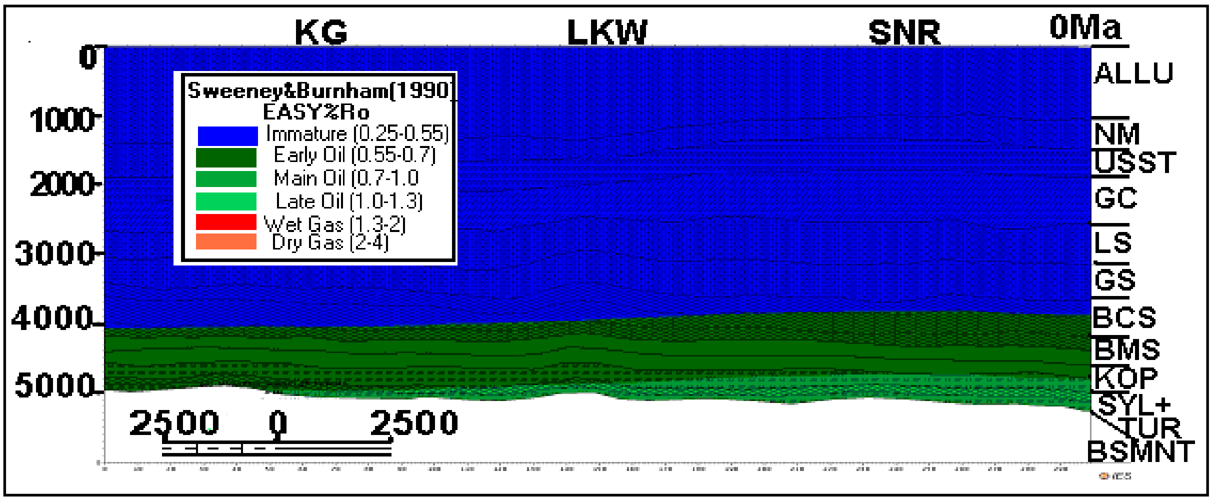


Figure-5: Oil window maturity of source rocks in modeled MK-SNRI section at 0Ma

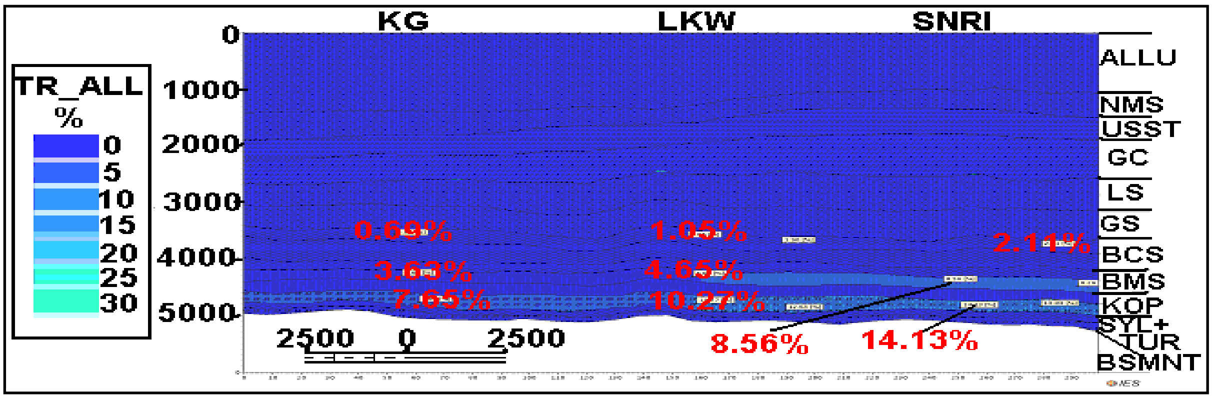


Figure-6: Kerogen transformation of source rocks in modeled MK-SNRI section at 0Ma

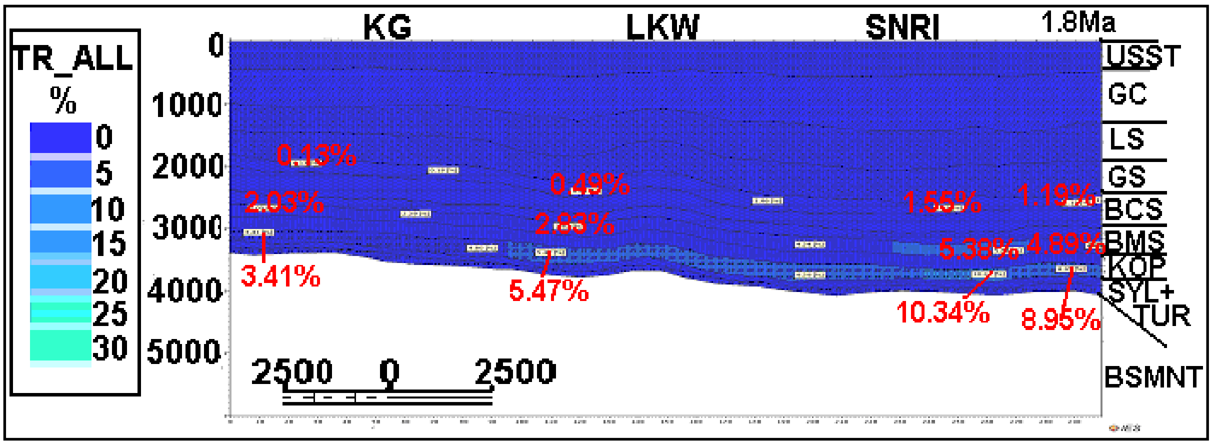


Figure-7: Kerogen transformation of source rocks in modeled MK-SNRI section at 1.8Ma

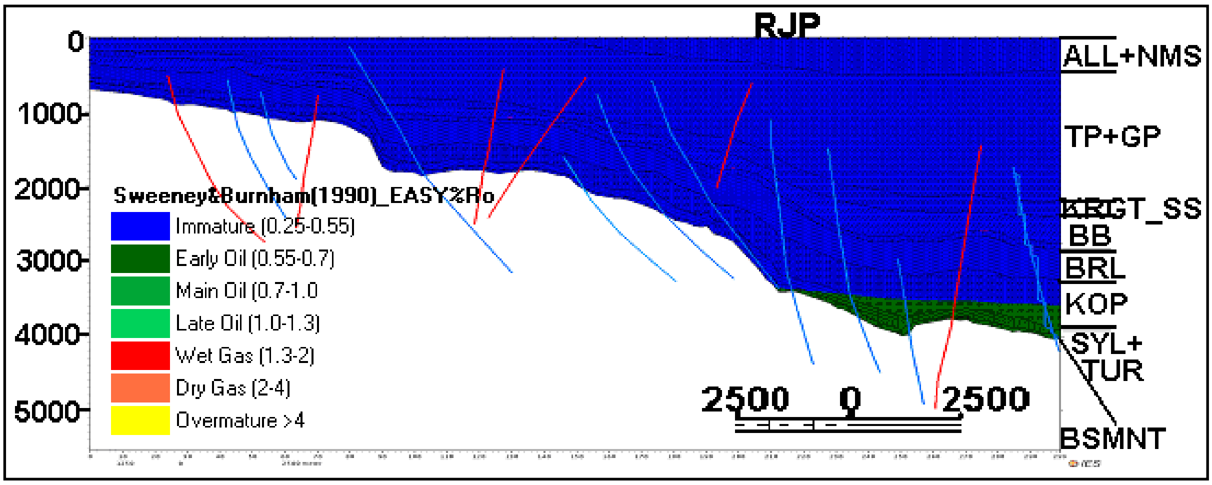


Figure-8: Oil window maturity of source rocks in modeled RJP section at present day

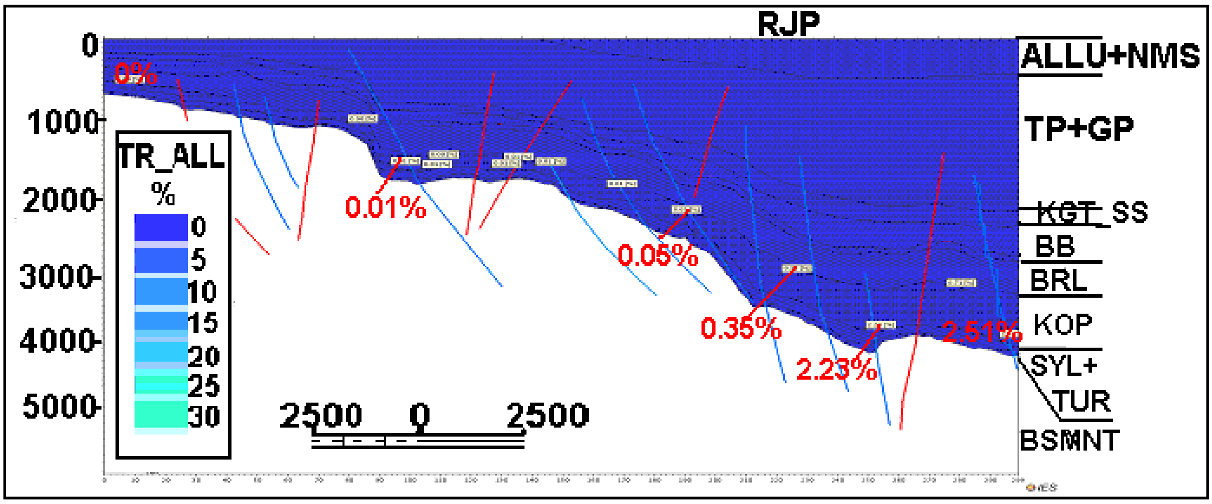


Figure-9: Kerogen transformation of source rocks in modeled RJP section at present day