EFFECT OF OVERPRESSURED SYSTEM ON HEAT FLOW MODELING AND HYDROCARBON MIGRATION: AN EXAMPLE FROM KRISHNA OFFSHORE BASIN, EAST COAST, INDIA

Ranajit Das [1*], Prasanta Nayak, Neeraj Sinha [1], B K Patel [1]

[1] "B" Wing, 5th Floor, PHQ, DAKC, Petroleum Business [E&P], Reliance Industries Limited Thane-Belapur Road, Koparkhairane, Navi Mumbai- 400 709. India, Tel: 0091-22-303 71444, Fax: 0091-22-303 71499.
[*] E-mail: Ranajit.Das@ril.com

Very low salinity water of about ~7000 ppm has been sampled from “upper bathyal” reservoirs of early Paleocene age. The overlying middle and upper Paleocene strata deposited under similar bathymetric condition are having normal marine water salinity ~34000 ppm. The underlying late Cretaceous sequences overlie the older Mesozoic rift and drift sequences, which wedge out against the basement high. The top of this sequence is marked by a continuous strong reflection event (FIGURE 1). The Paleocene sequence shows development of an organized channel system originating from the west. The Paleocene channel sands were deposited as canyon fill; the depth of the canyon at places exceeds 200 mts and back cuts the shelf. The channels show a strong amplitude seismic character with well-defined base (FIGURE 1, FIGURE 2).

The low saline water is rich in bicarbonate and the sediments are rich in calcite and siderite cements. A meteoric water refreshment of marine aquifer is likely to be the most plausible mechanism to explain the occurrence of such water chemistry. More interestingly, the low saline water happens to occur within an active overpressure system. Evidences of migrated hydrocarbon sourced from algal type organic matter is indicated by the presence of higher hydrocarbon components up to C35 and strong even to odd dominance within the C10-C34 range in dissolved hydrocarbon GC. The timings of such events of hydrocarbon generation and migration, water recharge and overpressure development are very crucial to study the behavior of petroleum system. Numerical basin modeling and simulation through Petromod 1D and 3D modules of IES Germany, have been performed to evaluate the significance of various conceptual scenarios. 1D thermal calibration and maturation history in relation to overpressure development at the well position is discussed here. This emphasizes the effect of overpressure on the thermal maturity and possible hydrocarbon migration events.

Thermal and pressure modeling and its calibration are of importance due to the heat retention on account of overpressure related thermal blanketing. The present day measured thermal gradient is reflective of such thermal compartments in the system. Combined pressure and thermal calibration helps us to introduce physical variability into the system in order to fine-tune the migration models (TABLE1, FIGURE 3 and FIGURE 4).

Linking the salinity variation and overpressure development it can be reasonably argued that fresh water recharging is contemporaneous to early Paleocene period (~66-63 Ma) or happened during lowstand phase at the end of the early Paleocene depositional unit (~63 Ma). Overpressure development at this position is bi-modal and oldest event is modeled at ~ 63 Ma onwards and the younger one started building up sharply since 37 Ma. The hydrocarbon migration from Turonian source unit is modeled to have started since ~32 Ma in and around the model location. Although the reservoir sands show good porosity, presence of primarily lighter hydrocarbon components and some medium components in formation water are suggestive of ineffective diffusive migration. The present system does not show any evidences for extensive flow path fluxing (slug/ bulk phase migration/ direct transport by water). The ineffective migration might be due to the presence of this pre-existing pressure seal.

FIGURES

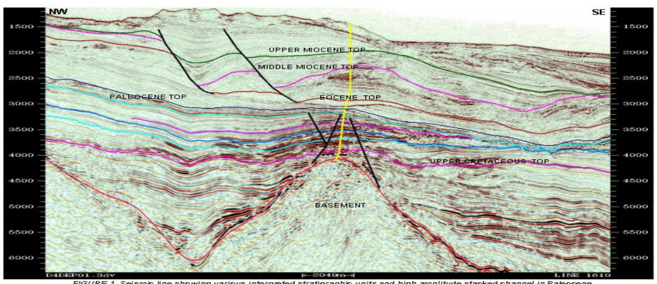

FIGURE 1. Seismic line showing various interpreted stratigraphic units and high amplitude stacked channel in Paleocene.

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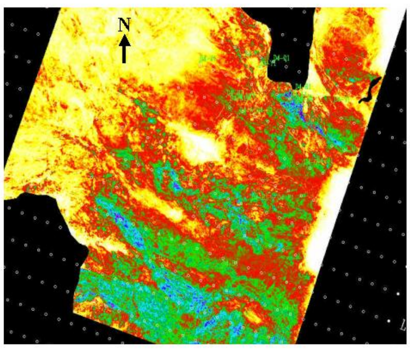

FIGURE 2. Stratal amplitude slice of upper Paleocene sequence showing development of channel systems *(Blue-green color indicates high amplitude facies, while red and yellow indicates low amplitude facies).*

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Name	Top	Bottom	Present Thickness	Eroded Thicknes	Deposition Age from	Deposition Age to	Erosion Age from	Erosion Age to	Lithology	Thermal compart ments
	[meter]	[meter]	[meter]	[meter]	[Ma]	[Ma]	[Ma]	[Ma]		
Sediment Surface			1446.00							
Pliocene_Recent	1446.00	1550.00	104.00		5.30	0.00			Shale_HC	Unit with High thermal outflow
Lt_Miocene	1550.00	1660.00	110.00		10.40	5.30			Shale_HC	
Mid_Miocene	1660.00	1770.00	110.00		16.60	10.40			Shale_HC	
Ely_Miocene_2	1770.00	1890.00	120.00		19.44	16.60			Shale_HC	
Ely_Miocene_1	1890.00	2070.00	180.00		23.70	19.44			Sh90Sst8Lst2_HC	
Lt_Oligocene	2070.00	2770.00	700.00		32.38	23.70			Sh90Sst8Lst2	
Ely_Lt_Oligocene	2770.00	3110.00	340.00		36.60	32.38			shale_lowperm	Unit with low thermal outflow : overpre ssured
Ely_Eocene	3110.00	3150.00	40.00		57.00	52.00			shale_lowperm	
Lt_Paleocene_2	3150.00	3230.00	80.00		58.80	57.00			Sh80Slt20_LPLC	
Lt_Paleocene_1	3230.00	3270.00	40.00		59.71	58.80			Sh90Lst10_LPLC	
Mid_Paleocene	3270.00	3385.00	115.00		62.30	59.71			shale_lowperm_D4_MidPal	
Ely_Paleocene_6	3385.00	3440.00	55.00		63.06	62.30			Sh30Sst20Slt50_LPLC	
Ely_Paleocene_5	3440.00	3500.00	60.00		63.90	63.06			Sh60Sst40_LPLC	
Ely_Paleocene_4	3500.00	3560.00	60.00		64.73	63.90			Sh70Sst30_LPLC	
Ely_Paleocene_3	3560.00	3600.00	40.00		65.29	64.73			Sh45Sst50Lst5_LPLC	
Ely_Paleocene_2	3600.00	3630.00	30.00		65.71	65.29			Sh80Sst20_LPLC	
Ely_Paleocene_1	3630.00	3680.00	50.00		66.40	65.71			Sh10Sst90_LPLC	
Lt_Cretaceous_5	3680.00	3700.00	20.00		70.23	66.40			Sh70Sst30_HC	Unit with high thermal outflow
Lt_Cretaceous_4	3700.00	3740.00	40.00		77.88	70.23			Sh10Sst15Slt75_HC	
Lt_Cretaceous_3_SR	3740.00	3780.00	40.00		85.53	77.88			Sh90Sst10_HC	
Lt_Cretaceous_2	3780.00	3815.00	35.00		92.22	85.53			Sh60Sst10Lst30_HC	
Lt_Cretaceous_1	3815.00	3840.00	25.00		97.00	92.22			Sh60Sst5Lst35_HC	
Rift_Basement	3840.00	5840.00	2000.00		170.00	150.00			BASEMENT	
	5840.00									

TABLE 1. Thermal compartments as proposed in the model. Geologically constrained with observed pressure-temperature gradients, salinity data and iterative reasonable calibration.

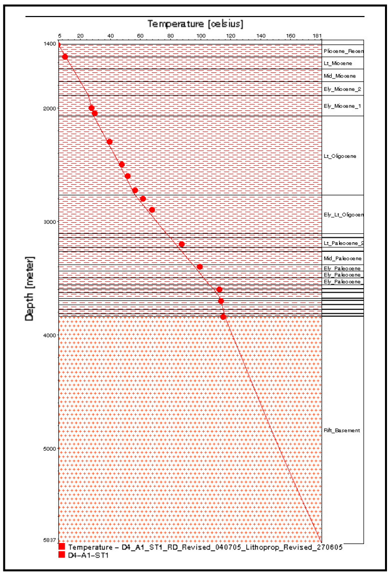

FIGURE 3a

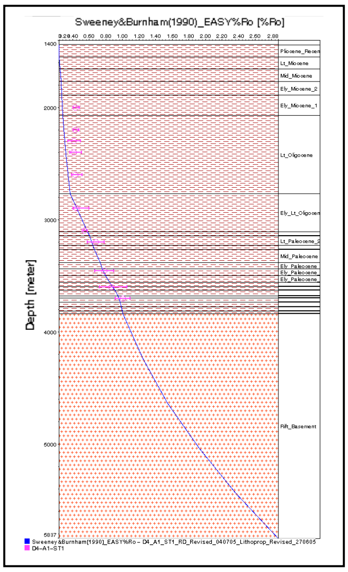

FIGURE 3b

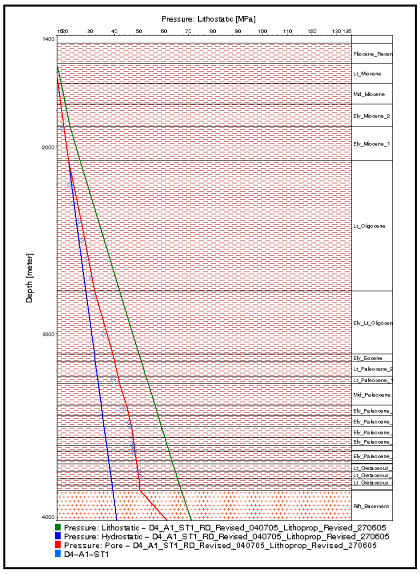

FIGURE 3c

FIGURE 3. Thermal and pressure calibration as achieved through physical property variation amongst the differentiated units. Normal lithoproperties could not bring satisfactory calibration.

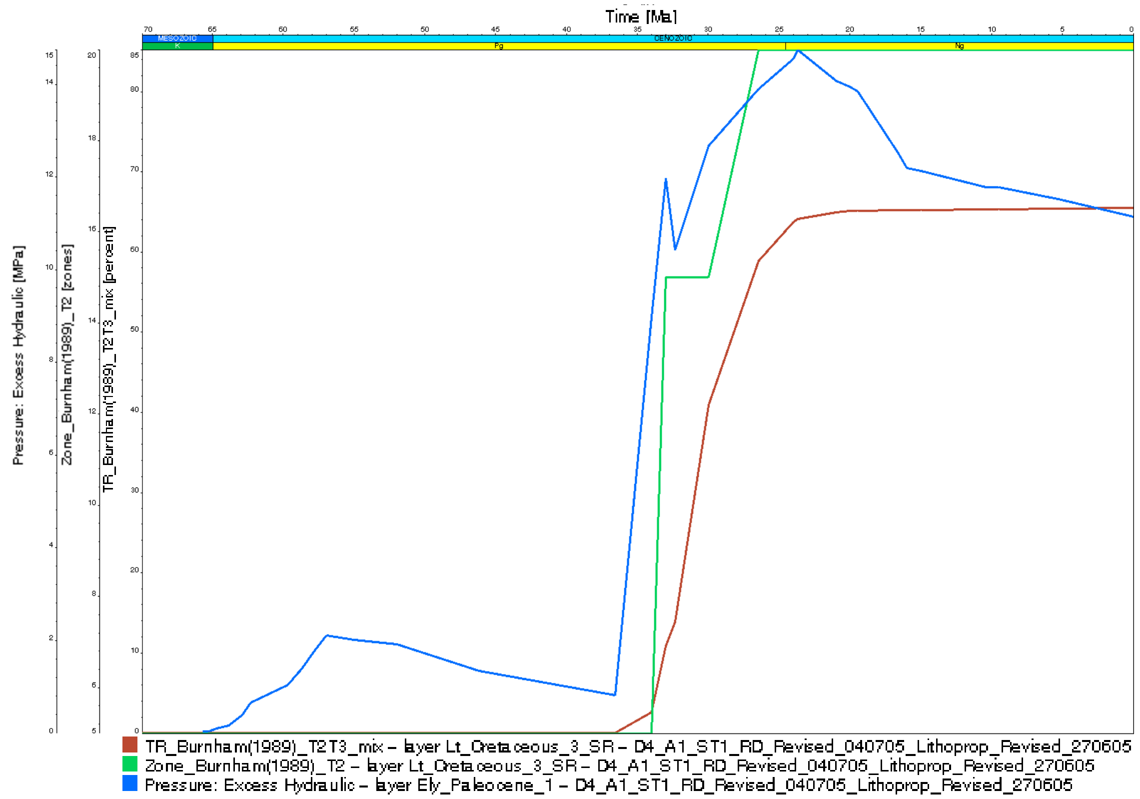

FIGURE 4. Maturation (Zone_Burnham, 1989_T2), Migration (TR_Burnham, 1989_T2T3_mix) of Turonian source rock unit is younger than over pressure (excess hydraulic) generation in overlying early Paleocene unit. Overpressure in early Paleocene unit is bi-modal and generated since ~63 Ma and ~37 ma. Maturation, expulsion, primary migration from Turonian source unit started since ~ 32 Ma. Pre-existing over pressure zone may act as pressure seal opposing effective hydrocarbon migration.

References

- Unpublished Laboratory analysis results and reports of RIL, India prepared by Core Lab Jakarta.
- Integrated Exploration Systems (IES), 2005, IES PetroMod Release 8.0: Software and Documentation

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