Sedimentary Characteristics and Lithological Trap Identification of Distant Braided Delta Deposits: A Case on Upper Cretaceous Yogou Formation of Termit Basin, Niger

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SUMMARY

Lithological trap identification in thin sand and thick shale layers is still a challenge for hydrocarbon exploration. Based on the high-resolution sequence stratigraphy theory and the establishment of high resolution sequence stratigraphy framework with seismic-well tie, the dynamic deposition process of braided river delta sands on late Cretaceous Yogou formation has been analyzed on 62 wells in passive rift Termit basin with multi-stages depressions and reversals. (1) Six kinds of sedimentary microfacies and three major reservoir sands with multi-stages stacking and lateral migration are in Yogou formation; (2) Based on Accommodation space/Sediments supply change and the deposition progress, sedimentary facies distribution in each member of YS3 sub-formation has been done according to sands thickness statistics of sedimentary micro-facies, narrow-time seismic attributes and slices analysis, multi-sources braided river delta depositional model has been concluded; (3) Based on source rock and caprock evaluation, with reservoir sands distribution and faults impact on Yogou formation of Termit basin, four types of traps, including structure-lithology, Structure-strata, stratigraphic and lithology are concluded. Traps influencing factors, i.e., structure geometry, sands distribution, paleotopography, stratigraphy cycling, sand/shale lateral connection, reservoir quality and so on, have different impacts on these traps, and different lithologic-stratigraphy traps have different exploration risks. Structure geometry and sands distribution are very important for the structure-lithology traps; structure geometry and paleotopography are the key factors in Structure-strata traps. Sands distribution and reservoir quality can be focused on lithology traps. Moreover, paleotopography and sand/shale lateral connection are significant on stratigraphic traps. Therefore, different hydrocarbon accumulation types of lithological traps have been established.

Key words: A/S, Sedimentary characteristics, RMS, Lithology trap, influencing factors

INTRODUCTION

As M.c.Pherson mentioned (M.c.Pherson, 1988), braided river delta is rich in sands and gravels, formed by braided rivers system influxing into stagnant water, and there are many classification schemes about braided river delta models, i.e., shallow or deep water kinds (Zhu Xiaomin, 2013), gentle or steep slope types (Yu Xinhe, 2008), progradation or retrogradation sorts (Wang Yue, 2015; Li Shunming, 2011; Zhou Hongrui, 2006), and distant or nearby models (Zhou Lihong, 2013; Yang Fan, 2010) with no consistency. Different evolution stages of sedimentary basin cause the different controlling factors in deposition progress of braided river deltas.
Since the 1970's, the exploration level of most hydrocarbon basins has been so high in all around world, and most of traps have been found in relatively regular anticlines. The next step is to find newly subtle traps, i.e. lithologic stratigraphy traps. Carl (1880) found various, different shape, unknown, and unpredictable non-anticline reservoirs (Pang Xiongqi, 2007). Following "non-structural trap" (Wilson, 1934 (Niu Jiayu,2005)) and "stratigraphic trap" (A.I.levorsen, 1936, (Jiao Hansheng, 2000)), A.I.levorsen (1966) pointed out subtle trap concept systematically, and M.T.Halbouty (1972) (Zhang Wei, 2006) included stratigraphic trap, unconformity trap and paleo-topographic trap into subtle traps, but used rarely at that time. Professor Jia Chengzao (2003) suggested "lithologic stratigraphy trap" instead of "subtle trap" in 2003. For reasons of the difficulty of the trap identification, irregular shape, trap scale, low seismic technology accuracy, and high risk of oil/gas exploration, most of overseas oil company do not willing to explore litho-strata traps.

For thin sand and shale interlayers in braided-river delta front deposits, based on high-resolution sequence stratigraphy (HRSS), this text discusses sands progradation and retrogradation through the dynamic depositional progress, considering about tectonic evolution of Termit basin, sedimentary micro-facies characteristics of the 3rd member of Yogou formation, sands or shales thickness distribution of micro-facies statistics, multi-provenance supply sedimentary model on upper Cretaceous period, sands distribution evolution with seismic attributes prediction and well logs.
Moreover, this text also evaluates source-reservoir-caprock condition on TOC, HI, and Kerogen maturity for source evaluation, sand thickness and porosity distribution for reservoir evaluation, and shales density, thickness, porosity and permeability for caprock evaluation.
And then it shows favourable areas on Fana uplift-Yogou slope southeast Termit basin for depression tectonic background, slope paleotopography, near hydrocarbon center, sand-shale interlayer associations, and discusses influencing factors about structure geometry, paleotopography, sands distribution, sand-shale lateral connection, reservoir quality on four kinds of lithologic traps, i.e., structure-lithology, Structure-strata, stratigraphic and lithology traps.
Finally, this text concludes the hydrocarbon accumulation model of four kinds of lithologic traps in upper Cretaceous period of Termit basin, and predicts risks and targets of lithologic traps for great support to oil-gas exploration of Termit basin.

METHOD AND RESULTS

1. High-resolution sequence stratigraphy framework

In early Cretaceous period, Termit basin went through thick alluvial fan – river sands during rifting period continental environment from Valanginan to Albian stage in K1 formation with an intact the 2nd grade sequence. In late Cretaceous period, it became a limited-sea basin in Donga-Yogou-Madama formation from Cenomanian to Masstrichtian stage. In the early epoch, Neo-Tethys and south Atlantic oceans invaded into Dinga and Moul depression, thick and dark marine shales distributed in the whole area, interbedded with thin and fine sands deposits with retrograding sequence stratigraphy stacking pattern, especially in Turonian stage (Lv Mingsheng, 2012) Donga formation. In the late epoch, two oceans retreated and disappeared from Termit basin, with sands and shales interlayers distributed in the whole basin, with retrograding sequence stacking pattern. Especially in Maastrichtian age, thick braided river channel sands overlaid vertically in Madama formation, indicating relatively high hydraulic power in depositional progress (Figure.1). Therefore, another the 2nd grade sequence includes low-stand system tract (LST) in early Donga formation, transgressive systems tract (TST) from middle Donga to early Yogou formation, high-stand systems tract (HST) from late Yogou to late Madama formation (Figure.1).

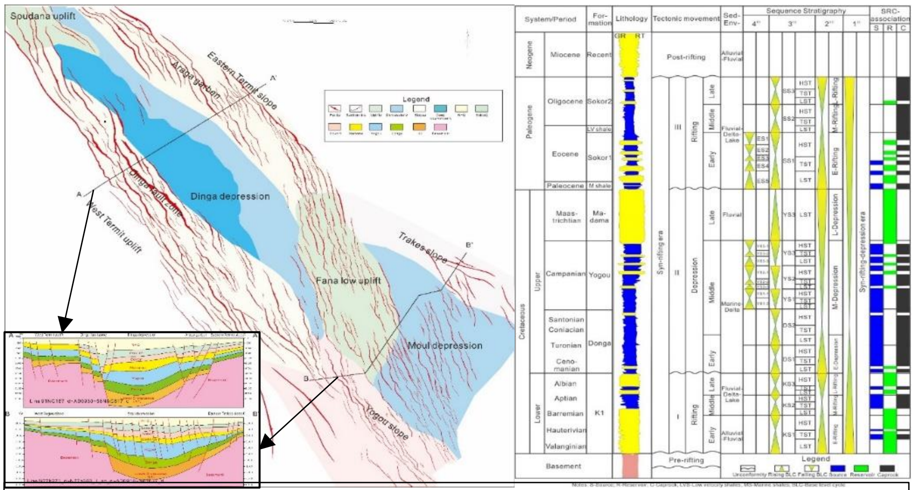


Figure.1 Tectonic structure and high-resolution sequence stratigraphy of Termit basin (left figure: tectonic structure on Yogou formation of Termit basin; right figure: high resolution sequence stratigraphy framework of Termit basin. Notes: BLC–base level cycle, LST – low-stand system tract; TST – transgressive system tract; HST – high-stand system tract; BLC – base level cycle; S – source rock; R – reservoir; C – cap rock)

There are two unconformities between K1 and Donga formation, between Madama and Sokor1 formation, and they are the boundary between lower Cretaceous, upper Cretaceous epoch and Paleogene period. Combined with logging data, choosing high continuity and high amplitude seismic axis which can be searched for whole area in Sokor and Yogou formation (Figure.2), the 3rd grade sequence stratigraphy can be further divided. Sokor1, sokor2 and sokor3 sub-formations can be classified in sokor formation in the 3rd grade, and ES1-ES5 members are identified in sokor1 sub-formation. YS1, YS2 and YS3 sub-formations are divided in the 3rd grade, and YS3-1-YS3-3 members can be identified in YS3 sub-formation. High or low amplitude caused by impedance difference reflects sand-shale deposits homogeneity, the continuity and frequency of seismic axis gives the information about sands continuity of lateral and planar distribution, and also the hydrodynamic condition in deposition process.

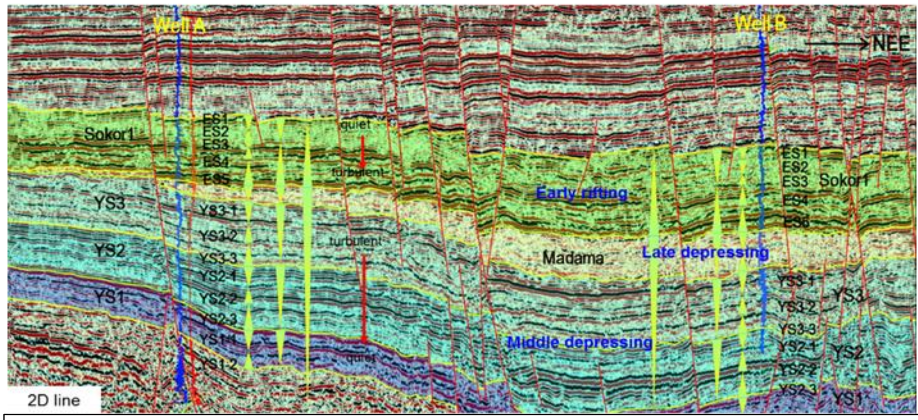


Figure.2 Seismic well tie tectonic evolution in Termit basin (the left figure shows tectonic evolution and high-resolution sequence stratigraphy classification on seismic well tie data from Campanian to Eocene period, 2D line in Yogou slope. Hydrodynamic condition changed from quiet to turbulent and then to quiet, with different BLC changes in different stages)

According to HRSS and seismic and logging data, considering sands progradation and retrogradation dynamic process, Yogou formation are divided into three sub-formations, showing coarsening upwards deposits, with funnel shape gamma (GR) and resistivity (RT) logs, and from low to high amplitude and frequency seismic changes, which indicates getting higher hydrodynamic power upwards. The upper YS3 sub-formation deposits marine braided delta front interlayers, with medium-low GR and medium-high RT logs, corresponding with high amplitude, medium continuity and medium-high frequency seismic characteristics; the middle YS2 sub-formation is grey or dark grey thick marine shales, interlaid with thin sands layers, with high GR, low RT logs, corresponding with medium-high amplitude, high continuity and high frequency seismic characteristics; the lower YS1 sub-formation has dark grey thick marine shales, without sand layers, with high GR, low RT logs, corresponding with high amplitude, high continuity and medium frequency seismic responses. Furthermore, YS3-1/YS3-2/YS3-3 member (Figure.2), corresponding to three sand group can be partitioned in the main target layer YS3 sub-formation, and sands in three members are unstable. Different BLC change of depositional layers can be caused by different paleotopography in depression period. Progradation and coarsing upwards deposits are located on upper slope, near provenance supply, which is sandy upwards and shaly downwards; Retrogradation and fining upwards deposits are located on lower slope, near depositional center, which is shaly upwards and sandy downwards.

2. Sedimentary facies and sands distribution

Based on HRSS division and correlation, with seismic interpretation results, top Yogou structure, bed thickness and paleotopography are analyzed. Two sags, two uplifts, two fault steps and two slopes are the structure characters of Termit basin, and the main Dinga sag with Dinga fault step in west and Araga graben in east, the secondary Moul sag with Yogou slope in west and Trakes slope in east, and Soudana uplift in north, Fana uplift between two sags. Tethys ocean in north is unconnected with Dinga sag, the Atlantic Ocean in south connected with Moul sag during Campanian stage Yogou formation, forming a limited sea and continental provenance depositional environment. Provenance in YS3 sub-formation came from the east, the northwest and the southwest, and continent sands supply was relatively more than a vast sea environment (Zhao Ning, 2015). Marine – braided delta deposits, including braided delta front sands and seashore shales, were in Yogou formation of Termit basin, using 62 wells logging, mud logging and 11607km^2 3D seismic data. Sedimentary facies include submarine distributary channel (SDC), mouth bar (MB), sand sheet (SS), coast shale (CS) and bathyal sea shale (Figure.3).

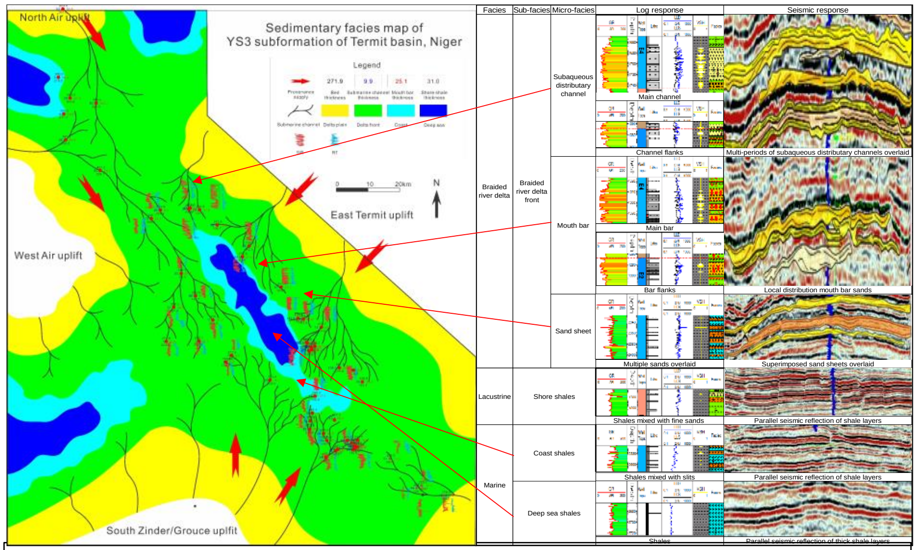


Figure.3 Sedimentary facies distribution and well-seismic temple of Termit basin (left figure: sedimentary facies distribution of Yogou formation in Termit basin using well logging and seismic data; right figure: well seismic samples in Termit basin.)

Table.1 Sedimentary micro-facies sand thickness statistics of YS3 sub-formation in blocks of Termit basin (notes: Bed-strata layers of YS31, YS32, YS33, SC-submarine channel, MB-mouth bar, SSS-sand sheet sands, CS-coast shale.)

Thickness	Yogou slope (17)			Fana low uplift (8)			Soudana uplift (9)			Dinga fault step (6)			Araga garben (7)			Termit west uplift (3)			Lake Chad (4)		
	max	min	average	max	min	average	max	min	average	max	min	average	max	min	average	max	min	average	max	min	average
Bed(m)	470.3	177.0	324.0	506.4	354.5	423.9	553.6	306.5	418.8	342.7	190.8	265.2	315.8	198.6	243.9	308.0	271.9	290.6	288.9	247.3	266.8
SC(m)	110.1	10.4	52.6	186.7	23.0	141.9	73.7	0.0	35.9	81.7	9.0	34.1	154.5	13.5	63.6	31.1	6.5	15.9	138.2	35.4	67.4
MB(m)	72.2	8.6	31.6	87.1	36.7	58.5	102.7	9.0	38.6	53.5	4.1	16.0	72.6	14.5	35.0	49.6	15.5	30.1	35.1	9.5	17.9
SSS(m)	108.8	13.4	70.1	103.0	25.9	75.3	102.4	23.5	55.0	46.1	10.9	34.9	54.7	13.0	35.5	45.9	25.8	34.2	42.0	8.1	25.7
CS(m)	282.9	90.3	169.9	188.4	116.8	148.4	371.0	219.5	288.2	292.3	95.0	180.4	142.1	68.5	109.9	226.1	181.4	210.5	209.2	122.3	156.0

Based on the sedimentary facies analysis and bed thickness, all micro-facies thickness statistics of 62 wells in YS3 sub-formation of seven Termit basin structures, i.e., two uplifts, two fault steps, two slopes and lake Chad, vertical reservoir – caprock combination condition can be analyzed. Yogou slope, Fana uplift and Soudana uplift are the major sediments discharging area, average cumulative bed thicknesses of these areas are more than 300m, Dinga fault step, Araga graben and west Termit platform and southern DC are relatively small (up right Figure.4). According to the average cumulative braided delta front sands thicknesses in Fana uplift is larger than Araga graben, and far more than other Termit structures (comparing upper right and lower right Figure.4), the main provenance supply in YS3 sub-formation comes from east Termit basin, and sands goes from Araga graben to Fana uplift. SCs thickness shows provenance supply direction. The average cumulative SCs thickness in Fana uplift is more than 140m, far more than other Termit structures (lower right Figure.4). The secondary provenance supply comes from southwestern upper Yogou slope, most of sands are SSs (lower right Figure.4), with average cumulative thickness nearly 70m, lower than Fana uplift (Table.1, Figure.4).

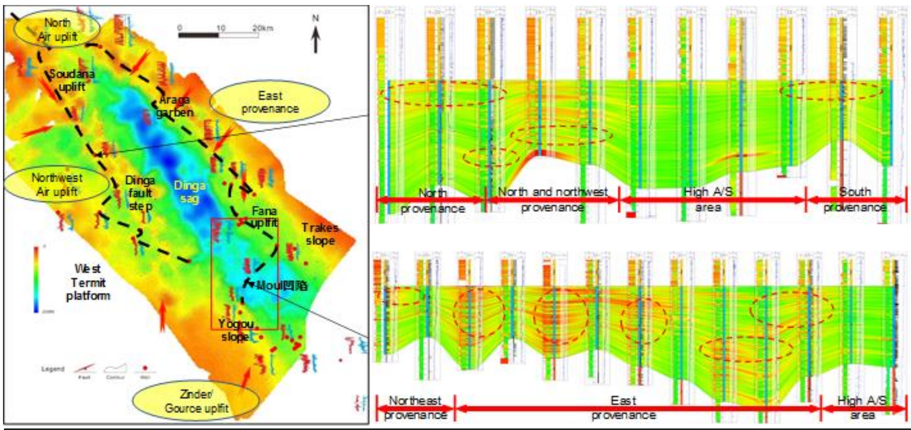


Figure.4 Bed thickness of Yogou formation and sands correlation in Termit basin (left figure shows bed thickness of Yogou formation in TWT scale; upper right figure is sands correlation through Soudana uplift-west Termit uplift-Dinga faulted steps; lower right figure is sands correlation through Araga graben-Fana uplift- Yogou slope)

With the high resolution of seismic data lateral prediction and well logging vertical prediction, sedimentary micro-facies sands distribution in each zones can be predicted by seismic attributes, slices and seismic inversion. And as we know, seismic resolution is the key factor to study the sequence stratigraphy and sedimentology by seismic data, and the maximum vertical resolution is 1/4 wavelet length (Sheriff R E, 2002). The average acquisition accuracy of seismic data in study area is 50-60Hz, and the seismic velocity in Yogou formation of upper Cretaceous epoch is 1900-2300m/s. Therefore, the minimum identified sands thickness is 31.67-46m. This resolution is far less than the required accuracy of lithology traps study. However, the geologic statistics of sands distribution in each horizon with seismic attributes slices can show sand distribution evolution both vertically and laterally.

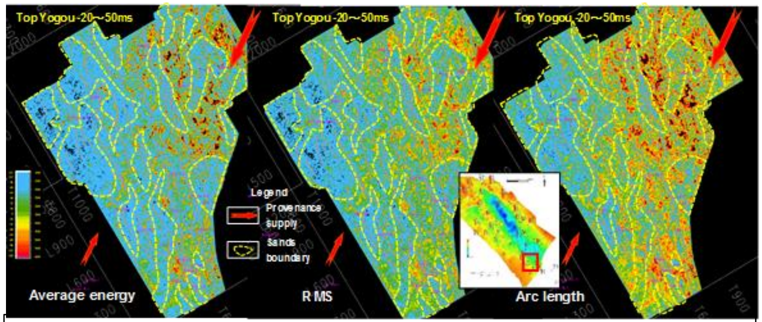


Figure.5 Comparison of average energy, RMS and arc length on top Yogou from up 20ms to low 50ms in Yogou 3D, south Termit basin (the same time widow, different results by different seismic attributes)

Seismic attributes can give us information about sand-shale distribution, sedimentary facies, fluid filling condition or reservoir properties from seismic data directly or extracted by digital conversion, and more truthful than seismic convention for less manual operation. There are multiple types of seismic attributes, such as amplitude, frequency, phase, energy, waveform and so on. Some of them are sensitive to reservoir lithology (Feng Y, 1999), some of them are sensitive to porosity liquid (Cooke D, 1999), some are useful for abnormal body underground (Cooke D, 1999), others can reflect sedimentary cycles (Wang Tianqi, 2003) in the geological history. Moreover, sedimentary face can be got in one seismic attribute or multiple seismic attributes together (Lin Zhenliang, 2009). Amplitude attribute is useful for quick change with thin sand-shale interlayers both vertically and laterally in braided river delta front deposits (Halbouty M．T, 1982). Such as Yogou 3D area in south Termit basin, with the same time window from +20ms to -50ms of top Yogou, average energy, RMS and arc length attributes show different results. Average energy is more obscure than RMS, because its average algorithm can’t give impedance difference between thin sands and shale interlayers. Arc length is more sensitive than RMS, especially in faults area, because wave length is not stable and shows abnormal reflection (highlights) in faults area. These highlights are along with faults direction, misleading as sands distribution. RMS is more effective method for sands distribution prediction for its amplifying the difference of thin sands and shale interlayers impedance, and not relate to sample interval, avoiding faults impact on sands distribution prediction (Figure.5).

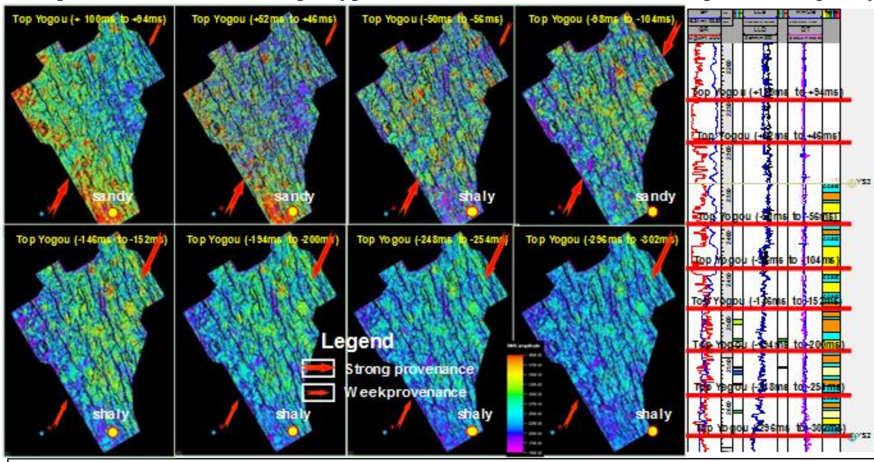


Figure.6 6 micro-seconds seismic-well tie RMS attribute slices of YS3 sub-formation in Yogou slope, south Termit basin (from the bottom to the top, provenance supply changed from northeast in YS3-3 stage and from southwest in YS3-1 stage)

Seismic attributes abstraction includes profile attributes, horizon attributes and 3D attributes. In the 5th grade of high resolution sequence stratigraphy framework (zones), short time interval (1/4λ) of RMS seismic attributes extraction can show quick evolution of braided river delta front sands distribution both in lateral and in planar. Such as in Fana uplift submarine channel showed frequent migration laterally and progradation vertically, and formed multi-periods stacking channel belts, moving to Dinga sag. These submarine channel belts are near 110km, with area of 355km^2 (YS3-1 zone), and changed into single submarine channels, with decreased length of 58km, and reduced area of 82.4km2 (YS3-3 zone). Another useful method is short time interval RMS slices. It can not only shows braided river delta front sands progradation and retrogradation evolution, but also indicates strong or weak provenance supply in different stages. Such as 6 micro-second RMS slices in Yogou slope (Figure.6), sands were gradually migrating from north to south, from east to west, and provenance supply came from northeast in YS3-3 stage and from southwest in YS3-1 stage, which indicated provenance supply change of Yogou slope in Termit basin. Moreover, in Fana uplift of west

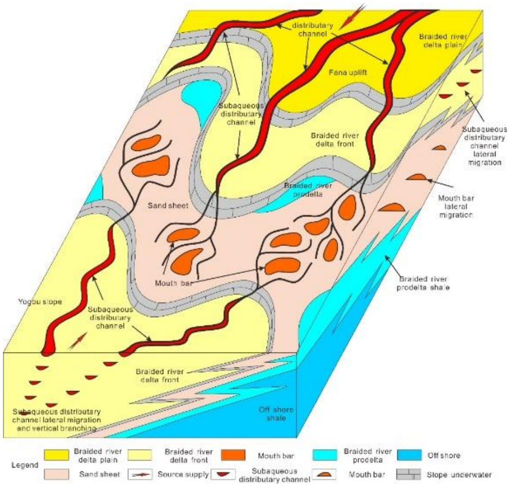


Figure.7 Sedimentary model of Fana uplift-Yogou slope of YS3 sub-formation in Termit basin (multi-provenance supply with different strength, showed submarine channels lateral migration and vertical change.)

Termit basin, with 10 isochronous RMS strata slices of YS3-2 stage, sands were migrating from the east to the west from the bottom to the top, and showed an intact BLC cycle change vertically.

Seismic-well tie is useful to sands distribution prediction. With sedimentary micro-facies sand thickness in 62 wells in each member of YS3 sub-formation, and RMS seismic attributes distribution, sands distribution prediction can be done.

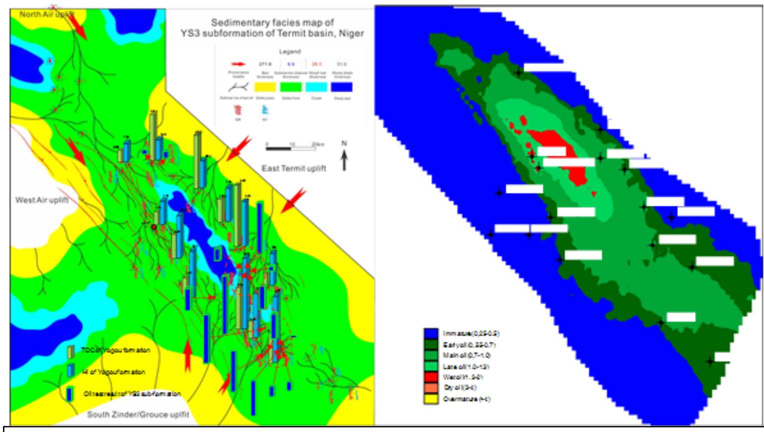


Figure.8 Hydrocarbon index -TOC- oil test-sedimentary facies and hydrogen maturity distribution of Yogou formation in Termit basin (left figure: TOC, HI and oil test results of wells on sedimentary facies map of Termit basin; right figure: thermal evolution simulation result of wells in Termit basin)

3. Sedimentary model

With the 2D seismic lines interpretation and structural mapping, 62 wells bed thickness and sedimentary micro-facies thickness indicate provenance supplies in Campanian period coming from primary eastern uplift, and braided river delta was widely spreading around Araga garben, Dibeilla structure and Fana uplift. The secondary provenance supply comes from northwest Air uplift and southwest Zinder uplift, and distal braided river delta front sands distributes near Dinga fault belts in the west of Termit basin and Yogou slope area in the southwest of Termit basin. Moreover, provenance supplies from east uplift and southwest Zinder uplift joint together at Moul sag. Therefore, an assembly sedimentary model of braided river delta coming from opposite directions was established. In this sedimentary model (Figure.7), sands distribution was controlled by submarine channels migration. Three belts can be identified in this model. The upper belt is braided river delta plain, sands supply was relatively strong and stable, and most of distributary channels above sea level were stacking vertically with lateral migration. Meanwhile, upper sea braided channel belts were formed by wide channels of large distribution and thickness. The middle belt is braided river channel front, distributary channels went into sea, and subaqueous distributary channel with lateral migration were formed, with narrow channel width and decreased sand layers thickness gradually. Later subaqueous distributary channels incised early channels or mouth bar sands, and large distributed subaqueous distributary channel belts with fine sand sheets were formed. The lower belt is braided river prodelta, and most of marine shales deposited with sea shore shales transition for weak hydrodynamic condition.

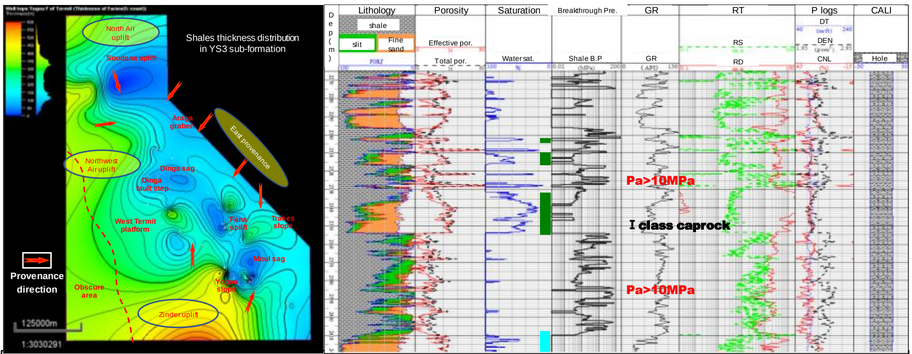


Figure.9 Cumulative thickness contour of offshore shales and single well cap rock sealing condition analysis of YS3 sub-formation in Termit basin (left figure: offshore shale thickness contour, left outside of the red dotted line is an imaging area lack of data.; right figure: cap rock evaluation in Niger, from LI Zaohong, 2014)

4. Lithologic strata traps evaluation and types

Source rock evaluation: Mature hydrocarbon source rock and fertile hydrocarbon supply are the precondition and requirement of large scale lithologic traps relied on. In different periods of serval types of oil and gas basin (J. Connan, 1974), the threshold of maturity of source rock is 65℃. The buried depth of Yogou formation in Termit basin is normally 2300－2800m, and the average geothermal gradient is 3.1-3.4℃/100m, so the ground temperature is more than 71.3-95.2℃. Therefore, source rock in Yogou formation were mature and in the range of large hydrocarbon generation. Based on shale samples of 16 wells in Termit basin, TOC (Total organic carbon) and HI (Hydrocarbon index) showed Dinga sag in center and Moul sag in southeast were hydrocarbon kitchens of Termit basin with high hydrocarbon-generating density and good oil/gas shows (Figure.8 left). From the maturity distribution of source rock, shales in Dinga sag with deeper buried depth was mature, and over-mature with gas bearing in Dinga sag center (Figure.8 right). However, shales in Moul sag was in early-mature or mature stage. From the oil test results

Table.2 Log criteria of cap rock evaluation in Termit basin (From LI Zaohong, cap rock evaluation in Niger, 2014)

DT (us/f)	RHOB (g/cm3)	Total thickness (m)	Single layer thickness(m)	Class	effectiveness
>185	<1.9	<20	<2	Fake	none
115~185	1.9~2.25	>20	>2	III	Heavy oil cap
80~115	2.25~2.6	>20	>2	II	Normal oil cap
<80	>2.55	>20	>2	I	Gas cap

of drilled wells in Yogou formation, most of oil in structure traps was discovered on Fana uplift and Yogou slope. Therefore, an oil accumulation model of hydrocarbon supply in two sags with near source accumulation was established.

Cap rock evaluation: Cap rock is more important in effective lithologic traps forming. Shales should go through serval diagenetic evolution progresses (Lv Yanfang, 1996), and then has the sealing ability. This ability is more relevant to the diagenesis, the deeper buried depth, the higher shales diagenetic degree, and the displacement pressure goes higher to reach the oil/gas sealing ability (Fuguang, 1995). The parameters for evaluating the sealing ability are porosity, permeability, density, specific surface area, microscopic pore structure and so on. According to shales sealing ability analysis of wells in Termit basin (Figure.9, Table.2), shale interlayers were very low porosity (1-10%), low permeability (2-50md), high density (2.35-2.65g/cm3), large total shale thickness (100-400m), with more than 3m single layer thickness, large shale ratio (52-70%)。Shales thickness around Dinga and Moul sags was larger than 200m, but relatively smaller in the center of the two sags. This is another evidence of far provenance supply of YS3 sub-formation. Moreover, comprehensive evaluation of cap rock in Yogou formation of Termit basin showed the 1st grade gas cap with very good sealing condition.

5. Influencing factor and oil accumulation model

Structure-lithologic, Structure-strata, stratigraphy, and sand lens are four kinds of lithologic traps, and oil accumulation model of lithologic traps in Termit basin was established according to 13026km 2D and 11607km2 3D seismic data observation and 62 drilled wells analysis (Figure.10). Except serval favorable and common lithologic traps conditions, i.e., depressing basin evolution, slope paleotopography, near hydrocarbon center, sand-shale interlayer associations, influencing factors of three types of lithologic traps are different.

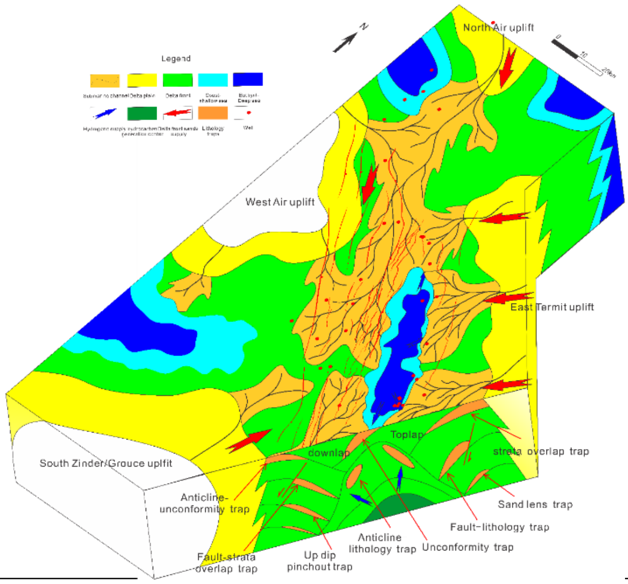
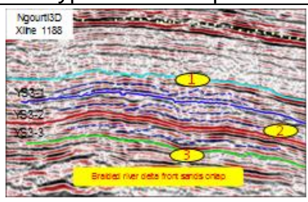
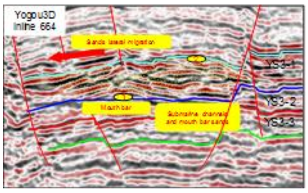
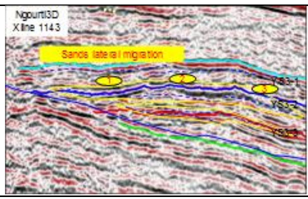


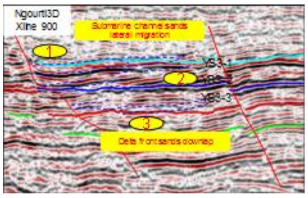
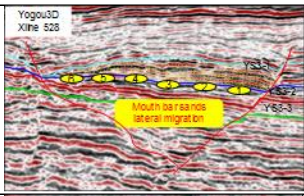
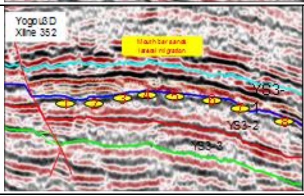
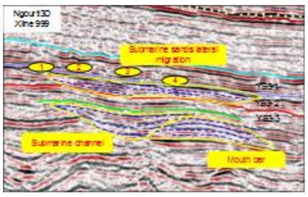
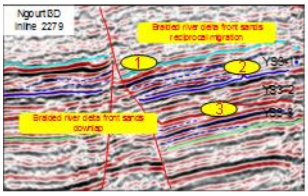
Figure.10 Sedimentary and reservoir model of YS3 sub-formation in Termit basin (on Fana uplift and Yogou slope, structure-lithologic, Structure-strata, stratigraphy, and sand lens four kinds of lithologic strata traps of eight subtypes are classified)

Structure lithology traps:

On the structure high of Yogou slope and Fana uplift, favorable structure features for multiple faults constructed fault lithologic and anticline lithologic traps (Table.3). These traps were controlled by structure condition and sands-faults allocation. Faults were not only oil-gas migration tunnels, but also lateral sealing surfaces. For large faults, reverse fault blocks were not favorable for oil accumulation as up-dip block jointed with thick and blocky braided river sands in Mandama formation, and oil leaked and escaped from the sands. However, normal fault blocks may be favorable with good sands-faults allocation. For small faults, both normal fault and reverse fault blocks were favorable for oil accumulation. Such as the lithologic trap in normal fault blocks southern Yogou slope, with "convex top - flat bottom" shape of mouth bars and "flat top - convex bottom" of submarine channels showing multiple sands migration. This trap area is 27.5km2, with 70ms amplitude. This kind of trap is more common in the study area, high risk on caprock and sands connection on both sides of faults.

Table.3 Types, cases and risk assessment of lithologic-stratigraphic traps in YS3 sub-formation of Termit basin

Trap type		Trap element	Typical seismic profile	Risk evaluation	
structure-lithology	anticline-lithology	area, buried depth, closure amplitude, sands distribution		S：90%, √ R：90%, √ C：30%, ? M：80%, √ T：80%, √ P：80%, √	Favorable：S, R, M, T, P； Unfavorable：C
	anticline lithology	area, buried depth, closure amplitude, sand-shale connection		S：90%, √ R：90%, √ C：30%, ? M：80%, √ T：50%, ? P：60%, ?	Favorable：S, R, T (small fault throw), M； Unfavorable：C, T (large fault throw), P
structure-strata	Anticline un-conformity	area, buried depth, closure amplitude, paleotopography, sands distribution		S：90%, √ R：80%, √ C：30%, ? M：80%, √ T：80%, √ P：80%, √	Favorable：S, M, T, P； Unfavorable：C

	fault-strata overlap	area, buried depth, closure amplitude, paleotopography, sand-shale connection		S：90%, √ R：80%, √ C：30%, ? M：80%, √ T：50%, ? P：60%, ?	Favorable：S, R, T (small fault throw), M； Unfavorable：C, T (large fault throw), P
strata	un-conformity	sands distribution, paleotopography, sand-shale connection		S：90%, √ R：80%, √ C：30%, ? M：80%, √ T：80%, √ P：80%, √	Favorable：S, R, T, M, P； Unfavorable：C
	strata overlap	sands distribution, paleotopography, strata evolution		S：90%, √ R：80%, √ C：60%, ? M：80%, √ T：70%, ? P：80%, √	Favorable：S, R, M, P； Unfavorable：C, T (small scale)
lithology	turbidite sand lens	sands distribution, reservoir quality		S：90%, √ R：70%, ? C：90%, √ M：80%, √ T：70%, ? P：90%, √	Favorable：S, C, M, P； Unfavorable：T (small scale), R (porosity unclear)
	up dip pinch out	sands distribution, reservoir quality, strata dip angle		S：90%, √ R：70%, ? C：90%, √ M：80%, √ T：70%, ? P：90%, √	Favorable：S, C, M, P； Unfavorable：T (small scale), R (porosity unclear)

Structure strata traps: For structure strata traps, anticline-unconformity and fault-strata overlap are more common (Table.3), controlled by structure background or paleotopography. The former is common in slope belts around depression basin sags, caused by braided river delta front sands progradation and vertical staking on local anticlines, with a relatively large scale. Such as the anticline-unconformity trap in southeast Fana uplift, and the area is 24.3km2, with 173ms amplitude (Table3. Anticline-unconformity trap). The main risk in this kind of trap is the sealing ability, and composite evaluation is relatively low. Therefore, it is a favorable type of lithologic trap in this area. The latter is common in slope belt around sags of fault-depression basin or depression basin with inherited faults, caused by braided river delta front sands overlapped and then incised by later faults, with a relatively small scale. This kind of trap is very common in Termit basin (Table3. fault-strata trap), and the main risk is caprock and sands connection on both sides of faults, with high risk evaluation.

Strata traps: In center Yogou slope and west Fana uplift near Dinga sag, strata of onlap, downlap, toplap are always obvious, and sands of progradation or retrogradation are very clear. Strata traps are very common in these area, composed with sand lens.For strata traps, sand-shale allocation combination on sequence boundary both up and down are very important, including unconformity and strata overlap traps. The two are formed in the process of the progradation or retrogradation of braided river delta front sands around the slope of Dinga and Moul depression, controlled by sands shales connection, paleotopography, sands distribution and strata cycle combination. The risk of unconformity trap is whether regional caprocks have or not (Table.3 strata unconformity trap), with low comprehensive evaluation. The risk of strata overlap trap is not only whether regional caprock have or not, but also large or small trap scale, and high comprehensive evaluation. Such as multiple sets of reservoir-caprock combination both vertical and lateral (Table.3 strata overlap trap), formed by quick strata overlapping of multi-periods braided river delta front sands. The sand combinations are thin with large area, more than 20km2, and low comprehensive evaluation.

Lithology traps: Near the center of Dinga and Moul sags, thin sands of braided river delta front flew directly into onshore - shallow sea as up dip pinch out sands or slid down to bathyal sea - deep sea as turbidite sand lens. These sands were string bead or fan shape as point provenance supply, or belt shape as line provenance supply, with thin and fine sands interlaid by thick shales as effective caprocks. However, these sands or traps were discontinuous, and small scale with single one and large scale with combination. Such as in central-east of Fana uplift, these sand lens traps are 36km2 large area and 270ms traps amplitude (Table.3 sand lens traps), with low risk of comprehensive evaluation. Moreover, up dip pinch out traps were caused by braided river delta front sands planar migration and good up dip lateral sealing (Table.3 up dip pinch out traps), with small scale and high overall evaluation.

CONCLUSIONS

Termit basin,deposited braided river delta in Campanian period of passive rift basin, has characteristics of abundant bar sands supply, quickly changing and frequently migrating submarine channels and mouth bars with progradation and retrogradation BLC cycles, multi-stages stacking pattern in geological histroy, special paleotopography and faults distribution caused by multi-periods depressing and rifting of basin evolution, and can form a lot types of lithologic strata traps by thin sands and shales interlayers.

Structure-lithology, Structure-strata, stratigraphic and lithology are concluded. Traps influencing factors, i.e., structure geometry, sands distribution, paleotopography, stratigraphy cycling, sand-shale lateral connection, reservoir quality and so on. Structure geometry and sands distribution are very important for the structure-lithology traps; structure geometry and paleotopography are key factors in Structure-strata traps; paleotopography and sand-shale lateral connection can be focused on stratigraphic traps, and these traps risks on regional cap rock quality. Moreover, sands distribution and reservoir quality are key factors for lithology traps, and they risk on reservoir sands distribution.

ACKNOWLEDGMENTS

This article is based on some ideas about braided river sedimentary model on my project, I would thank our section head professor Zhang Guangya and section chief Mao Fengjun for giving me great instruction, and also thank my PHD adviser, my parents and my wife Mrs. Huang Jiangqin for giving me a great support to finish this paper work.

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