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Lithofacies Analysis and Reconstruction of Deformation Types of Cenozoic Sediments of Phú Khánh Basin

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Abstract: From Oligocene and Quaternary geological sedimentary section have six cycles corresponding to six sequences:
- Sequence 1: Eocene - early Oligocene ($E_2 – E_3^1$);
- Sequence 2: Late Oligocene (E_3^2);
- Sequence 3: Early Miocene (N_1^1);
- Sequence 4: Middle Miocene (N_1^2);
- Sequence 5: Late Miocene (N_1^3);
- Sequence 6: Pliocene - Quaternary (N_2 - Q).

Since then may establish three general integrated formulas between the lithofacies association series and sedimentary systems tract as follows:

1. Sedimentary lowstand systems tract (LST): LST = arLST + (ar + amr)LST + (amt + mt)/(amr + mr) LST + mrLST (1);
2. Sedimentary transgressive systems tract (TST): TST = MtTST + atTST + (amr + mr)/(mt + amt)TST + mtTST (2);
3. Sedimentary highstand systems tract (HST): HST = arHST + (ar + amr)HST + (amt+mt)/ (amr +mr)HST + mrHST (3).

Keywords: Sequence, lowstand, highstand, transgressive systems tract, parasequence set, parasequence, marine flooding plain.

1. Introduction

Phú Khánh basin was extended from coastal zone to deep water area in Central Việt Nam, bounded by latitudes 11^0N-14^0N and longitude 109^0E - 111^0E. The relief of the sea floor were differentiated into three zones:

- Inner shelf zone is flat and shallow area ranging from 0m to 200m water deep;

- Central zone is a deep sea area varying from 500m - 2500m due to sinking the outer shelf in late cenozoic period;

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- Outer uplifting zone has a complex relief due to the tectonic uplifting and young volcanic activity.

The content of this paper mainly presents results of analyzing the relationship between the lithofacies association series and sequence stratigraphy as follows:

1. Lithofacies analysis and intergrating the lithofacies association series and sedimentary systems tract (lowstand systems tract, transgressive systems tract, and highstand systems tract).

2. The syn-sedimentary fault pays an important role to create the aggraded wedge and significantly increase the thickness of sediments.

3. It is necessary to analyze the deformation of secondary basins and to reconstruct the secondary basins.

Since 1970 year, there have been many authors in the country and overseas researched on stratigraphy, sedimentology, geological evolution and evaluation of hydrocarbon potential of Phú Khánh basin [1,6,8,16]. Yet so far the relationship between lithofacies association and sequence stratigraphy in relation to sea level change over the period of secodary basin not to be made clear. Up to now have not clarified the laws of lithofacies change from inner shelf to outer shelf like? In addition, the relationship between the lithofacies association series and sedimentary systems tract of each sequence in relation to global sea level change and tectonic movements are very important but are not interested to research. The Eastern part of the Phú Khánh basin often called *deep water area*, but in fact it is a shallow water gradually sunk in late Cenozoic. The presence of the alluvial sand, deltaic sandy mud and shallow mud facies from the Oligocene to late Miocene proved Phú Khánh basin demonstrated the coastal and shallow water environments where were deposited the terrigenous sediments. The differentiation process of thermal subsidence created three different structural zones:

- Inner shelf is the depth varies from 0m to 200m water;

- Outer shelf (Centre zone) is the depth changing rapidly from 500m to 2500m due to cyclic thermal subsidence;

- Outer elevation zone is more shallow depth than varying from 1000m to 2000m due to uplifting movement.

An analysis of lithofacies in relation to sea level changes and tectonic movements may be an approach to understand the nature of the Cenozoic secondary basins forming to deformating processes.

2. Methodology

2.1. Definition of sequence stratigraphy based on lithofacies association

Based on the lithofacies analysis method [4,5,10] and the relationship between lithofacies association, sea level changes and tectonic movements [9,10,11,12,13,14], sequence stratigraphy may be defined as follows: “Sequence stratigraphy is arrangement rules of the lithofacies in horizontal and vertical direction of the certain stratigraphic framework in relation to the global sea-level changes and tectonic movements”.

2.2. Correlation between lithofacies association series and sedimentary systems tract

Each sequence composed of three sedimentary systems tracts corresponding to three lithofacies complex upward vertically as follows [3,4,5]:

- *Lowstand systems tract (LST)* was constituted by regressive associated lithofacies series simultaneously with the process of changing the shoreline degradation. Consequently, the sedimentation created the regressive monofacies and couplefacies being younger gradually changing from the continental to transitional and finally to the marine environment (Fig. 1, 2). In facts, the correlation between the facial association and the sedimentary systems tract may be expressed by an intergrated formula as follows:

LST = arLST + (ar+amr) LST + (amr + mr)LST + mrLST).

- *Transgressive systems tract (TST):* During the change of sea level from minimum to maximum position the correlation between the transgressive alluvial sand facies group (at), deltaic mud facies complex (at+amt), deltaic mud facies and shallow marine clay facies complex (amt + mt), deep marine mud facies group (mt) and marine flooding plain facies group (Mt) and Transgressive systems tract is expressed by an intergrated formula as follows:

TST = MtTST + atTST + (at + amt)TST + (amt + mt)TST + mtTST

- *Highstand systems tract (HST):* The changing of lithfacies has been taken place simultaneously with the process of migrating the shoreline to intermediate position between the maximum and minimum sea levels.

Depositional accommodation in the period of transgresion can be represented by a general formula combinating lithofacies and systems tract as follows:

HST = arHST + (ar + amr)HST + (amr +mr)HST + mrHST (Table 1).

Table 1. Relationship between the lithofacies association series and sedimentary systems tract (LST, TST, HST) of inner shelf and outer shelf in Phú Khánh basin

Sq. Stratigraphy		Inner shelf (shallow water)			Outer shelf (deep water)		
Sq	Systems tract	Structure	Lithofacies	Intergrated formula	Structure	Lithofacies	Intergrated formula
Sq	HST	ar, amr, amt, ar, amr	Regressive deltaic muddy sand and alluvial sand double facies complex alternated transgressive deltaic mud facies	amt / ar+amr	amr, mr, mt, amr, mr	Regressive deltaic sandy mud and marine mud and marine double facies complex alternated with transgressive marine mud facies	mt / amr+mr
	TST	Mt, amr, mt, amt	Transgressive deltaic sandy mud and marine mud double facies complex alternated with regressive deltaic mud facies	amr / Mt+mt+amt	Mt, mr, mt, amt	Transgressive deltaic mud and marine mud double facies complex alternated with marine mud facies	mr / Mt+mt+amt
	LST	ar, amt, amr, ar	Regressive alluvial sand and deltaic sandy mud double facies complex alternative transgressive deltaic mud facies	amt / ar+amr	amr, mt, mr, amr	Regressive deltaic muddy sand and marine mud double facies complex alternated with transgressive marine mud facies	mt / amr+mr

Note: ar: Regressive alluvial monofacies group;
amr: Regressive deltaic monofacies group;
at: Transgressive alluvial monofacies group;
amr: Transgressive deltaic monofacies group;
ar+amr: Regressive alluvial and deltaic couplefacies complex;
amr+mr: Regressive deltaic and marine couplefacies complex;
at+amt: Transgressive alluvial and couplefacies complex;
amt+mt: Transgressive deltaic and marine couplefacies complex.

3. Results

3.1. The correlation between lithofacies association series and sedimentary systems tract

1) The lithofacies association series of lowstand systems tract is determined from the boundary between erosion and accumulation area to all sediment and accumulation space. Thus, the need to recognize that the "sedimentary accumulation space" including the lithofacies distributing from continental to transitional and finelly to marine environment. The Phú Khánh basin was differentiated into two lithofacies zones: inner shelf and outer shelf zones (Fig. 1, 2 and Table 2).

- *In the inner shelf:* Integrated formula between lithofacies and systems tract is written as follows:

$$LST = arLST + (ar + amr)LST \quad (1)$$

This formula shows that the distribution of lithofacies in inner shelf is mainly composed of regressive alluvial gravelly sand facies group intercalated with regressive alluvial sand and deltaic sandy mud doublefacies complex (Fig. 1, 2). In seismic profile number VOR-93-101 one can clearly realize inclinating rude and chaotic wave field related to unidirection cross-bedding structure of river channel intercalated with aggradated wedge structure of submarine deltaic sediments [2, 4, 5, 10].

- *In the outer shelf:* General intergrated formula betwween the lithofacies and systems tract is expressed as follows:

$$LST = (ar + amr)LST + (amr + mt)LST \quad (2)$$

This formula shows that in the period of lowstand systems tract the regressive alluvial-deltaic doublefacies complex (ar + amr) are dominated in the sequences 1, 2 (Early and Late Oligocene) (Fig. 1, 2, 3). Meanwhile, in the sequences 3, 4 and 5 (Early, Middle and Late Miocene) it was dominated by the regressive deltaic sandy mud and regressive marine mud doublefacies complex (amr + mr).

From the inner shelf to the outer shelf, the boundaries of each sequence consists of three types:

- Type 1: Incised erosion carved by the river channel on which is filled with coarse-grained sediments (sand and gravel) cross bedding structure. On seismic sections show the crude, monoinclinal broken or messy wave field.

- Type 2: Unconformable boundary of weak abrasive surface signs carved by tidal channel during regression. Filled sediments are mainly poor sorted sandy mud.

Boundaries of type 1 and type 2 are characteristic in the inner shelf (Fig. 1, 2) .

- Type 3: Correlation conformity boundary expressed very clearly in the outer shelf. In the seismic profile, the wave field structure shows that the varying of grain size composition between the lower layer and the upper one due to change of the bottom depths from each other.

2) The lithofacies association series of the transgressive systems tract (TST)

- *In the inner and outer shelf basin:* The lithofacies associated distribution in inner shelf and in outer shelf is relative similar from each other. From the central area to marginal alluvial plain of basin was dominated the transgressive marine mud facies group alternated with deltaic sandy mud facies group gradually changing in space and in time. The lithofacies consist of two internated principle lithofacies complex:

+ Transgressive deltaic muddy sand and marine mud doublefacies complex;

+ Transgressive shallow marine grey-greenish clay facies group of marine flooding plain (Fig. 2).

Therefore, the intergrated formula of the lithofacies associated series and sedimentary systems tract may be expressed as follows:

$$TST = MtTST + (amt + mt)TST$$

Table 2. The lithofacies association series of systems tract in the seismic profile VOR-93-101

Age	Sequence	Systems tract		Intergrated formula of facial asociation and systems tract	
				Inner shelf	Outer shelf
$N_2 – Q$	Sq_6	Q^{**}	5 LST, TST and HST	5 cycles:a, am, m	5 cycles: a, am, m
		N_2^{*}	3 LST, TST and HST	3 cycles: a, am, m	3 cycles: a,am, m
		HST		amt/ (ar+ amr) HST	amt+mt/ (amr+mr) HST
N_1^3	Sq_5	TST		MtTST+(at+amt) TST	(am, m) TST
		LST		amt/ arLST+(ar+ amr) LST	amt+ mt/ (amr+ mr) LST
		HST		amt/ (ar+ amr) HST	amt+mt/ (amr+mr) HST
N_1^2	Sq_4	TST		amr/ (amt+ mt) TST	amr+mr/ (am, m) TST
		LST		amt/ (ar+ amr) LST	amt+mt/ (amr+ mr) LST
		HST		amt/ (ar+ amr) HST	amt+mt/ (amr+ mr) HST
N_1^1	Sq_3	TST		amr/ (amt+ mt) TST	amr+mr/ (amt+ mt) TST
		LST		amt/ (ar+ amr) LST	amr+mr/ (amr+ mr) LST
		HST		amt/ (ar+ amr) HST	amt+mt/ (amr+ mr) HST
E_3^2	Sq_2	TST		amr/ (amt+ mt) TST	amr+mr/ (amt+ mt) TST
		LST		amt/ arLST+(ar+amr) LST	amt+mt/ (ar+ amr) LST
		HST		amt/ (ar+amr) HST	amt+mt/ (amr+ mr) HST
E_3^1	Sq_1	TST		amr/ (amt+ mt) TST	amr/ (amt+ mt) TST
		LST		amt/ ar LST+(ar+amr)LST	amt/ (ar+ amr) LST

3) The lithofacies association series of the highstand systems tract (HST) (Tables 1, 2)

During sea level falling from the highest position to the intermediate position, the lithofacies association series between inner shelf and outer shelf is relatively clear different. In the inner shelf, the distribution of regressive alluvial sand facies group, regressive deltaic sandy mud and regressive marine clay double facies complex:

$$HST(inner) = (ar + amr)HST$$

Meanwhile, on the outer shelf the regressive deltaic mud facies group and regressive marine mud complex was mainly developed according to the following formula:

$$HST(outer) = (amr + mr)HST$$

Finally, the intergrated formula of the

lithofacies association series and sedimentary systems tract was represented as follows:

HST(inner + outer) = (ar + amr)HST + (amr + mr)HST

3.2. Determining the cause-effect correlation of the lithology and the tectonic activity

1) Characteristic deformation types of Phú Khánh basin

Fault deformation:

- Step subsidence fault according to meridian occured from late Miocene to Pliocen-Quaternary creating to destroying zone situated $109^0 30$ - 110^0E Meridian. Result of this fault led to the division continental shelf into two parts: inner shelf (0-200m deep water), and outer shelf (500-2500m deep water) (Fig. 1, 2, 3).

Lithofacies analysis on the basis of the seismic wave field of sediment N_2-Q in addition to the following information:

Sedimentary Pliocene-Quaternary thickness is varying from 500 to 1500m, including terrigenous sediments which form alluvial sandy gravel facies, deltaic clay facies and shallow sea clay facies brought by rivers originating from the Trường Sơn mountain range. The presence of thick terrigenous sediments of Pliocene-Quaternary in the deep water (1000m) proved the original was created sediments in shallow waters alternating continents. But due to fault activity levels drop them sink down deep water on the modern continental slope. This is easily misunderstood that Phú Khánh basin has been formed in deep water [1].

- Strike-slip fault distributed in longitude parallel run from more out of the shelf (Fig. 4, 5). Strike-slip fault with a very young age occur from the Pliocene to the Holocene formation of grooves 1-5km deep and from 1 to 10 km wide in Canion style. These large-scale trench formation mechanism differs from the trench dug carved by ancient rivers and underwater training nor carved bottom of the flow.

Strike-lip fault has created a large-scale destruction developing from Oligocene to Quaternary to migrate the sedimentary rock layers horizontally and vertically (Fig. 4, 5). The destruction zones due to strike-slip fault was expressed the seismic wave field behavior disorder, chaos, the layers of sedimentary rock is no longer the boundary of the layered structure. In sections S74-A-2-1 (Fig. 5) it shows that a dense strike-slip system cut through Late Quaternary sediments and down the Oligocene sedimentary rocks.

Deformation due to volcanic activity:

Volcanic activity are more mixed but ultimately Pliocene-Quaternary age with the following evidence:

- Sediment Pliocene-Quaternary been penetrated.

- Oligocene and Miocene sediments penetrated, folding and sagging thin neckties in the contact zone created a pseudo-onlap structure. In the space between the cross-cutting volcanic outer-shelf and sliding wall of inner-shelf in creating a folding structure of the Oligocene-Miocene sedimentary rocks that was truly deltaic shallow marine clay and sand facies underground like a separate sedimentary basins with the lacustrine and lagoonal facies like the analysis result of ANRECA project (Fig. 6).

Deformed by protruded basement:

In fact it is very easy to confuse “false grabens” with grabens, the original sedimentary basins with Oligocene deformated basins by pressing protruded basement in the form of up lifting blocks through the period (Fig. 7). Between up lifting blocks there are “false grabens” or “false half - grabens”. They are the “fragments” of secondary basin separated from a larger-scale original.

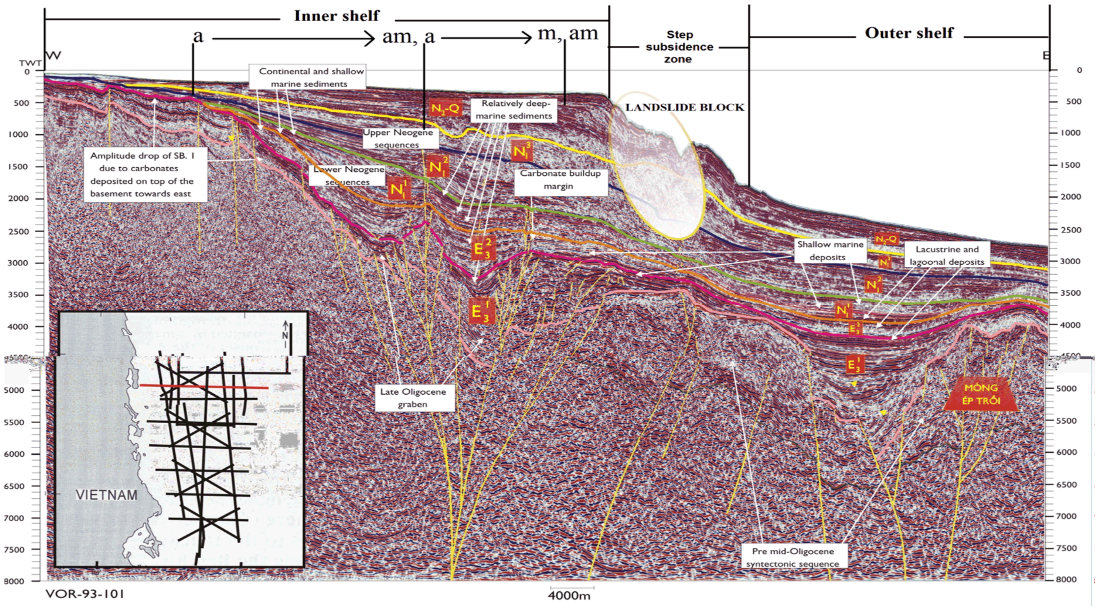

Fig. 1. Step fault zone at the longitude 110^{0}E divided into 2 halves: inner shelf at the depth of 0-200m and outer shelf from the depth of 500-3000m (Section SVOR - 93 - 101).

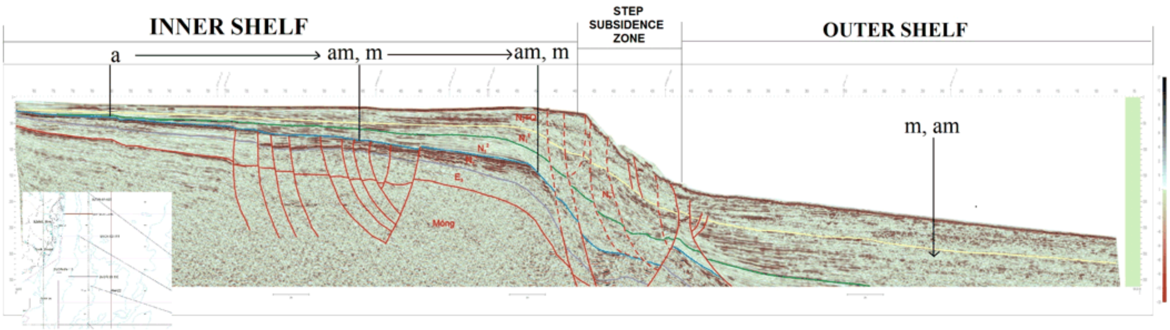

Fig. 2. Collapse-step fault zone at the longitude 110^{0}E divided the modern shelf into 2 halves: inner shelf and outer shelf (Section SVOR - 108).

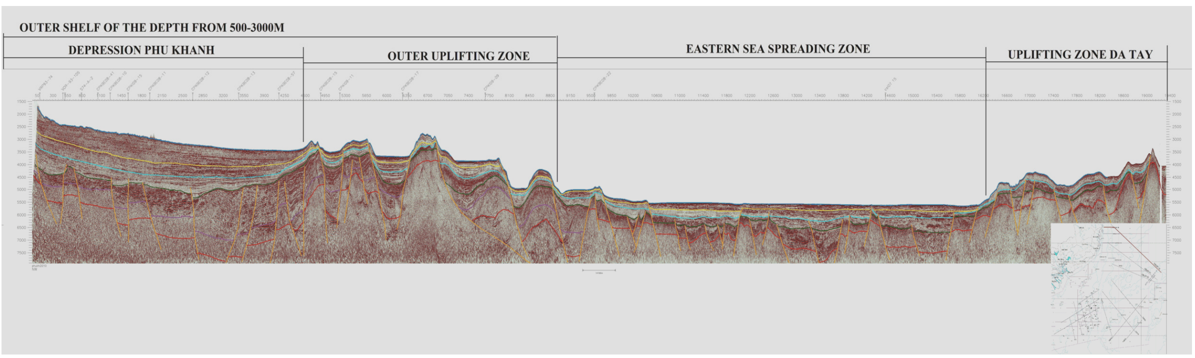

Fig. 3. Outer shelf of Phú Khánh basin situated in modern continental slope composed of Phú Khánh depression and outer uplifting zone (Section CLS 07 - 10).

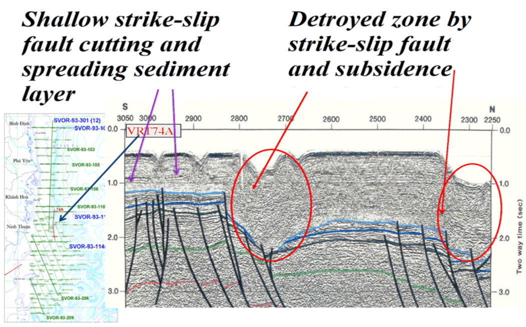

Fig. 4. Strike-slip fault destroyed the Quaternary sediment and tertiary sedimentary rocks (Section CLS 07 - 10).

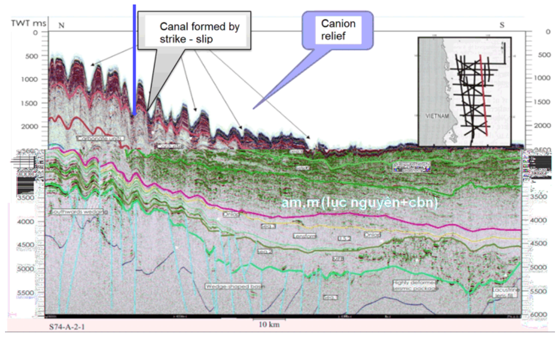

Fig. 5. Deformed sea bottom relief due to strike-slip fault system (Profile S74 - A - 2 - 1 in Phú Khánh basin).

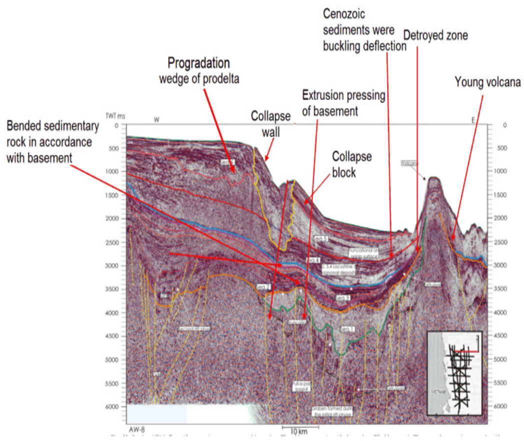

Fig. 6. Deformation due to young volcanic activity (Profile AW - 8 in Phú Khánh basin).

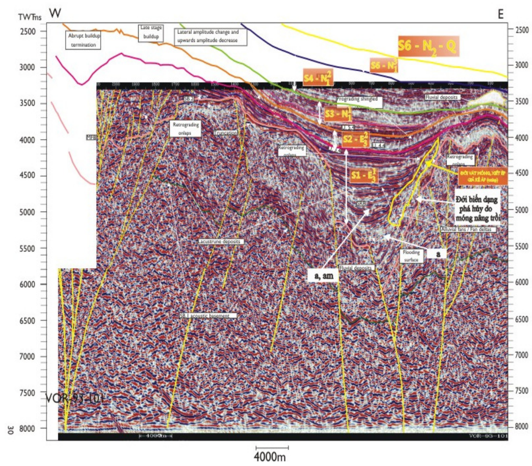

Fig. 7. Fault make Oligocene false grabens, pressing protruded basement, folding of the late Oligocene, early Miocene, middle Miocene sedimentary rocks (Profile VOR - 93 - 101, from ANRECA project).

2. The lithofacies change of sequences in relation to sea level changes and tectonic movements Phú Khánh basin

Sequence 1 - Early Oligocene (S_1 - E_3^1 PK) strongly deformated was expressed very clearly on the 2D seismic sections.

Fracture after sedimentation and upwelling phenomenon of basement led to the fact that Early Oligocene secondary basin becoming to "Pseudo-grabens" is easily confused with the original grabens (Fig. 6, 7). Early Oligocene sequence can be divided into 3 systems tract vertically from the bottom up: LST, TST and HST.

- Lowstand systems tract (LST) is characterized by the seismic wave field is very crude, chaotic distribution, and disrupted expression of coarse-grained sediments formed cross-layered oblique orientation deformed river bend fold and buckling deflection. Two edges of the "false grabens", create two contact zones of sediments with basement like "onlap structure":

+ Phase 1: occurs at the end of the early Oligocene sedimentary fold of the drop zone sag “false grabens’ due to heat sinking and erosion early Oligocene sediments on top of the Late Oligocene elevated block.

+ Phase 2: occurs at the end of the Late Oligocene folding and buckling deflection increases for early Oligocene sediments compared with sediments of late Oligocene (Fig. 7, 9). This condition is very important to create the strucrure traps and play of basement stone.

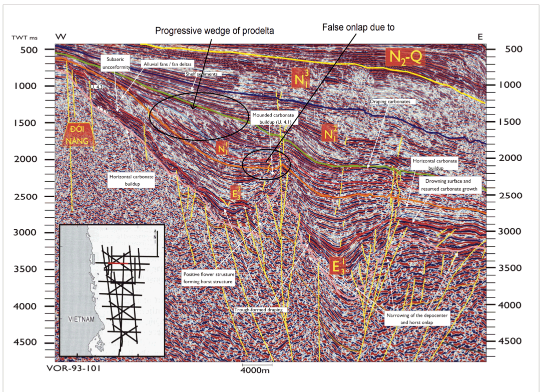

Fig. 8. Early-Midde Miocene lithofacies assoation of alluvial, deltaic and shallow water environment.

- South high advances and marine systems (TST/HST): Other with low marine domain system (LST) forming a off continental sedimentary minister complex domain dominated the marine transgression, and marine systems was characterized by deltaic complex minister and sea dominance which is reflected in the school section with strong reflection of seismic waves; parallel strokes reflecting the fine-grained sediment (powdered, clay) were deposited standing in hydrodynamic quiet environment.

2.2. Sequence 2 - Late Oligocene (S_2 - E_3^2 PK)

Unlike the early Oligocene sediments, in the Late Oligocene period increased volume significant delta and shallow sea facies, while reducing the volume of aluvial facies. So, the end of Oligocene has been formed a transgressive and higstand sedimentary layer (TST/HST) with good seal layer.

In lowstand systems tract period of late Oligocene Phú Khánh basin appeared more basins separated by basement differentiation that is shallow sea basin favorable for forming of good quality sources rocks.

2.3. Sequence 3 - Early Miocene (S_3 - N_1^1)

The boundary of sequence where the most on the shelf is in the region and beyond. It is eroded fluvial boundary during regressive phase of lowstand systems tract activities. On the seismic section it is characterized by rough waves, dashed inclined orientation expressed layered structure oblique cross the direction of the sandy river channel facies (Fig. 9, 11). Relative conformity boundaries of the sequence is very popular in outer continental shelf. This boundary was discovered due to difference of grain size between upper and lower sedimentary rock.

Pressed protruded blocks of Late Oligocene created the submarine island in the outer continental shelf to facilitate the formation and development of the coral reef from the Early Miocene period of lowstand systems tract of the 3rd sequence (LST - S_3 - N_1^1). In the margin of the basin there are existed two characteristic facial complexes: sand-clay facies of submarine delta with aggradation wedge structure then gradually shifted to the shallow marine sandy mud facies, finally sudden move to the shallow sea coral reef (Fig. 8) [15].

Transgressive systems tract and higstand systems tract of third sequence (S_3 - N_1^1) includes 2 alternating lithofacies complexes:

- Complex 1: Transgressive deltaic sandy clay facies and flood marine plain clay facies of transgressive systems tract (TST).

- Complex 2: Regressive deltaic mud facies of higstand systems tract.

2.4. Sequence 4 corresponding with Middle Miocene (S_4 - N_1^2) shows clearly in the seismic profile that the sedimentary thickness changes very quickly from the margin of the basin out characterized by 2 lithofacies complexes for inner and outer shelf:

+ Inner shelf:

- In the edge zone of basin: mainly is aluvial alternating deltaic sand facies (a/am) of thin sediment thickness.

In further area of the basin the thickness of sediments increased dramatically, mainly submarine deltaic sandy mud facies mixed shallow mud facies (am/m). In the seismic profile, uni-phase wave field is made up of progressive wedge (Fig. 9). However, the boundaries of the sedimentary units of prodelta make a white reflector, the wave field of the coarse grain size expression, the percentage of sand/clay >> 1, which is due to subsidence of rapid tectonic and sedimentary compensation process will very quickly exceed the amplitude of subsidence. In the vertical direction of the sequence, it is clearly expressed 3 systems tract: lowstand, transgressive and higstand system tract successive developing upward. In the transgressive systems tract section appears more aggradation wedge structure that demonstrates terrigenous sediments brought by rivers excess (Fig. 9).

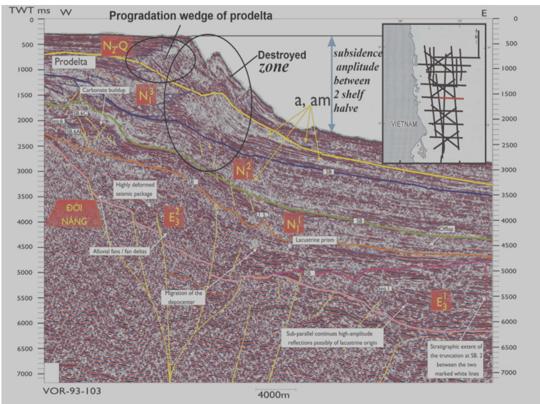

Fig. 9. Postsediment fault (N_2 - Q) divided the continental into 2 part: inner and outer shelf.

+ Outer shelf:

In addition to the depth of 500-2000m, and even up to 2500m (Fig. 3), Phú Khánh basin was formed and developed on an ancient continental shelf then divided, and differentiation sink down in the different depths. The term "deep waters" refers to the current deep water, but the Phú Khánh basin is formed on the shallow continental. However, strong subsidence activity is mainly related to the thermal sinking process cycle beveled the continental crust and associated with spreading of central zone of the Eastern Sea. In the outer shelf of the Phú Khánh basin the Middle Miocene sediments consists of many submarine coral reef on the ancient shelf.

2.5. Sequence 5 corresponding with Late Miocene (S_5 - N_1^3) the sediments dominated the gravels and sands alternated mud. As for the deep waters have all the sediments of continental, coastal and shallow sea like inner sediment above mentioned. Abrasive surface of upper Miocene roofs and the phenomenon of folding, faulting in form of positive flower developing in S_5 - N_1^3 due to the effect of spreading of the Eastern Sea.

Late Miocene sediments of inner and outer shelf is different from lithofacies and thickness. In a sequence, the greater thickness is surely related with aggradating wedge structure of submarine delta. The wave field of white reflection is characterized by percentage of sand rather then clay-rich sediments (Fig. 6).

2.6. Sequence 6 - Pliocen-Quaternary (S_6 - N_2 - Q)

Pliocene-Quaternary sediments are distributed not only in the inner shelf, but also in the outer one. However, the big thickness of the deposits of the inner shelf is concerned with the remarkable development of submarine deltaic terigenous lithofacies (Fig. 9). The Quaternary sediments of Phú Khánh basin is differentiated into 3 zones due to melting the pre-cenozoic continental crust distributed at different depths:

- Shallow shelf or inner shelf in depths of 0 - 200m;

- Deeper zone of outer shelf in depth of 500 - 2500m;

- Outer uplifting zone in depth of 500 - 1000m (Fig. 3).

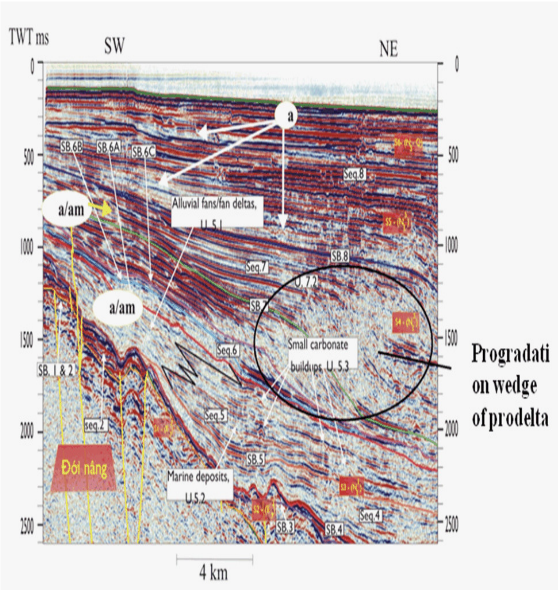

Fig. 10. The sedimentary thickness changes very quickly from the margin to center of the basin characterized by 2 lithofacies complexes: aluvi sand silt → canion sand silt clay (a/am_1 → am_2/m).

4. Conclusions

1. Phú Khánh basin have differentiation of geological structure in inner shelf located at a depth of 0-200m, and from 500-2500m for outer shelf. Fault systems at the meridian 109^0E - 110^0E was reactivated in the Late Miocene and Pliocene-Quaternary has created two different half-depth shelves.

2. Six sequences corresponding to six secondary basins controlled by cyclic subsidence of crust pre-cenozoic continental are as follows:

- S_1 corresponds to secondary basin Eocen - Early Oligocen (E_2 - E_3^1).

- S_2 corresponds to the secondary basin Late Oligocen (E_3^2).

- S_3 corresponds to the secondary basin Early Miocen (N_1^1).

- S_4 corresponds to the secondary basin Middle Miocen (N_1^2).

- S_5 corresponds to the secondary basin Late Miocen (N_1^3).

- S_6 corresponds to the secondary basin Pliocene - Quaternary (N_2 - Q).

3. Sedimentary environment evolution according to time and space from the margin to the center of the basin:

- From inner shelf to outer shelf space it may be identified a gradually change of the environments from dominated alluvial - deltaic to deltaic - marine environment.

4. The deformed activities occurs alter phase changing the geological structure, lying position and thickness of sedimentary rocks composed of: faulting, folding, extrusion presses of basement and, volcanic activity.

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