การสำรวจแหล่งทรายโดยการสะท้อนคลื่นไหวสะเทือนแบบแยกชัดสูงในพื้นที่นอกชายฝั่งทะเลของหาดจอมเทียน จังหวัดชลบุรี ประเทศไทย

นายทศพล วัฒนานุกูลวงศ์

วิทยานิพนธ์นี้เป็นส่วนหนึ่งของการศึกษาตามหลักสูตรปริญญาวิทยาศาสตรมหาบัณฑิต
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INVESTIGATION OF SAND RESOURCES BY HIGH RESOLUTION SEISMIC REFLECTION IN JOMTEIN BEACH OFFSHORE AREA OF CHANGWAT CHONBURI, THAILAND

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A Thesis Submitted in Partial Fulfillment of the Requirements
for the Degree of Master of Science Program in Earth Sciences
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ทศพล วัฒนานุกูลวงศ์ : การสำรวจแหล่งทรายโดยการสะท้อนคลื่นไหวสะเทือนแบบแยกชัดสูงในพื้นที่นอกชายฝั่งทะเลของหาดจอมเทียน จังหวัดชลบุรี ประเทศไทย (INVESTIGATION OF SAND RESOURCES BY HIGH RESOLUTION SEISMIC REFLECTION IN JOMTEIN BEACH OFFSHORE AREA OF CHANGWAT CHONBURI, THAILAND) อ.ที่ปรึกษาวิทยานิพนธ์หลัก: ศ. ดร.ธนวัฒน์ จารุพงษ์สกุล, 87 หน้า.

หาดจอมเทียน กำลังประสบปัญหาการกัดเซาะชายฝั่งอย่างรุนแรง ในอดีตมีการแก้ไขด้วยวิธีการต่างๆ แต่ก็ยังไม่ประสบความสำเร็จ ซึ่งการแก้ปัญหาที่ส่งผลกรทบต่อสิ่งแวดล้อมน้อยที่สุดและได้รับชายหาดกลับคืนมาเร็วที่สุดคือการเสริมทรายชายหาด แต่การเสริมทรายแต่ละครั้งต้องใช้ทรายในปริมาณที่มากและต้องมีการเติมทรายหลายครั้ง อีกทั้งทรายบกหรือทรายปากแม่น้ำมีราคาสูง จึงมีความจำเป็นต้องสำรวจพื้นที่ที่สะสมตัวของชั้นตะกอนทรายในทะเล

การสำรวจแหล่งทรายในครั้งนี้ได้นำเทคนิคการสะท้อนคลื่นไหวสะเทือนแบบแยกชัดสูงมาใช้ในพื้นที่นอกชายฝั่งทะเลหาดจอมเทียน จังหวัดชลบุรี ประเทศไทย ครอบคลุมพื้นที่ 72 ตารางกิโลเมตร การสำรวจโดยเทคนิคดังกล่าว ได้ภาพตัดขวางการสะสมตัวของชั้นตะกอน นำผลที่ได้มาแปลความหมายร่วมกับข้อมูลการเจาะสำรวจจำนวน 6 หลุม ในบริเวณพื้นที่ศึกษา หลังจากนั้น สร้างแบบจำลอง 3 มิติ ของลำดับชั้นตะกอนและประเมินศักยภาพของแหล่งทรายดังกล่าวเบื้องต้น

จากข้อมูลการคลื่นไหวสะเทือนบริเวณพื้นที่ศึกษาสามารถแปลข้อมูลประกอบกับข้อมูลหลุมเจาะได้ทั้งสิ้น 4 หน่วย (A – D) และสามารถคำนวณปริมาณสำรองแหล่งทรายได้ประมาณ 242 ล้านลูกบาศก์เมตร ข้อมูลหน่วย A มีความหนาเฉลี่ยประมาณ 3 เมตร กระจายอยู่บริเวณแนวกึ่งกลางของพื้นที่ศึกษา กระจายสลับเป็นช่วงสั้นๆ กับ ข้อมูลหน่วย B มีปริมาณจากการประเมินเบื้องต้นประมาณ 1.5 ล้านลูกบาศก์เมตร ข้อมูลหน่วย B เป็นมีความหนาเฉลี่ยประมาณ 9 เมตร เป็นแหล่งทรายที่อยู่ชั้นบนสุด บางพื้นที่มี ข้อมูลหน่วย A กระจายทับถมปิดทับด้านบนเป็นช่วงสั้นๆ มีปริมาณจากการประเมินเบื้องต้นประมาณ 62.5 ล้านลูกบาศก์เมตร ข้อมูลหน่วย C มีลักษณะเป็นร่องน้ำโบราณ ที่พบในพื้นที่ศึกษา มีความกว้างเฉลี่ยประมาณ 400 เมตร มีความลึกเฉลี่ยประมาณ 12 เมตร มีปริมาณจากการประเมินเบื้องต้นประมาณ 20 ล้านลูกบาศก์เมตร และ ข้อมูลหน่วย D เป็นกลุ่มข้อมูลที่อยู่ล่างสุดและมีความหนามากที่สุด โดยมีความหนาเฉลี่ยประมาณ 22 เมตร มีปริมาณจากการประเมินเบื้องต้นประมาณ 158 ล้านลูกบาศก์เมตร

ภาควิชา ธรณีวิทยา ลายมือชื่อนิสิต .....

สาขาวิชา โลกศาสตร์ ลายมือชื่อ อ.ที่ปรึกษาหลัก .....

ปีการศึกษา 2559

5672163423 : MAJOR EARTH SCIENCES
KEYWORDS: SEISMIC SURVEY / INTERPETATION OF SEISMIC / BEACH NOURISHMENT

TOSAPL WATHANANUKULWONG: INVESTIGATION OF SAND RESOURCES BY HIGH RESOLUTION SEISMIC REFLECTION IN JOMTEIN BEACH OFFSHORE AREA OF CHANGWAT CHONBURI, THAILAND. ADVISOR: PROF. THANAWAT JARUPONGSAKUL, Ph.D., 87 pp.

Jomtien beach has been facing with seriously coastal erosion nowadays. There are many solving erosion's problems in the past, but there is no right ways to succeed. The best and fastest restoration that least affects to the environment is Beach Nourishments. In each of nourishing sand, it has to use a huge of sand must usually be filled like a cycle and spent high prices with sand pit or estuary sand. It is necessary to survey deposited sediment layers in the sea.

For this sand resources survey, the technic has been used by high resolution Seismic Survey, it is of Jomtien beach offshore at Eastern, Thailand. Area covers 72 km^2. The result of this survey is cross section of deposited sediment. Then the result has interpreted with 6 boreholes of data logger in studied area.

From seismic data with data logger, it can separate 4 Unit; A – D. Unit A, thick sediment is about 3 m. that separate in the middle of studied area, and switch shortly with Unit B. Quantity of primary evaluation is about 1.5 m^3. Unit B, thick sediment on the top is about 9 m. Some area has been separated with Unit A shortly. There is evaluated primarily about 62.5 million m^3. Unit C, the characteristic is ancient channel. The width is around 400 m. The deepest is around 12 m. Quantity from primary evaluation is 20 million m^3. Unit D, it is on the lowest and thickest. The thickness is about 22 m. The primary evaluation is 158 million m^3. In the conclusion, the quantity of sand resources offshore Jomtien beach is from the seismic survey and interpretation with data logging. It is evaluated primarily potential sediment resources in studied area about 242 million m^3.

Department: Geology Student's Signature .....
Field of Study: Earth Sciences Advisor's Signature .....
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CHAPTER 1

Introduction

1.1 Sources and significance of the problems

The coast of Thailand is long about 2,600 kilometers. The coast has faced up with many coastal erosion problems long around 830 kilometers. Jomtien beach founded another problem place at Chonburi province is the high potential place of economic and social. Jomtien Beach, the high potential place, can help make tourism business income to our country more than 56,000 Million Bath per year (Aquatic Resources Research, 2011a). At present, Thailand has been severely facing the coastal erosion problems. To solve and protect the coastal erosions has 4 ways that are 1) To be gnore, 2) To move a place, 3) To make a stability of sea coast with a hard structure, 4) To make a stability of the coast without the hard structure. In the past, Marine Department's officials make a beach nourishment project at Pattaya and Jomtien beach to solve the coastal erosion, so they has founded important reserved sand for beach nourishing. The area of this project is around coastal Jomtien, and it covers along with area which is long about 14 km. The point of this survey is for beach nourishment at Jomtien and Pattaya beaches (Aquatic Resources Research, 2014).

For making a stability of the sea coast without the hard structure, an important form is nourishment the beach that the officials must take sand from many places to the coastal erosion places. Beach nourishment is how to increase restore the eroded beach. The solved problems which were difference ways with others have to add the sand around the beach. Factors solving problems with nourishing sand combine with a proper time and topography, also a proper of sand resources. The sand resources that are quality sand have sediment size like the old

sand around the beach which has had nourished, enough, short or long distance of transportation.

Nowadays, a proper and popular way to solve an erosion problem is beach nourishment which has to use amount of sand, and it has to prepare total reserved sand. The reserved sand can bring to nourish the beach which was done per each for making continually balance of the sea coast.

In conclusion, reserved sand's studies and surveys outside Jomtien offshore in Chonburi for reserved sand database on the seabed have potential to nourish the coast. For solving erosion problems in the present as well as the future temporarily are greatly necessary and important to nourish sand in Chonburi province and other places.

1.2 Objectives

1.2.1 To survey of sand with high-resolution seismic reflection profiles in Jomtien offshore beach in Chonburi province.

1.2.2 To explain to the sand layers of sedimentary stratigraphy, and to evaluate the primary potential sand resources.

1.3 Study area

Evaluating the potential of sand sediment and giving levels is outside in Jomtien offshore beach area, the east of Thailand; Chonburi province. It's on the North latitude 12° 45'35"-12° 54'31", moreover it has East longitude 100° 51' 21"-100° 51' 22" **(Fig.1)**.

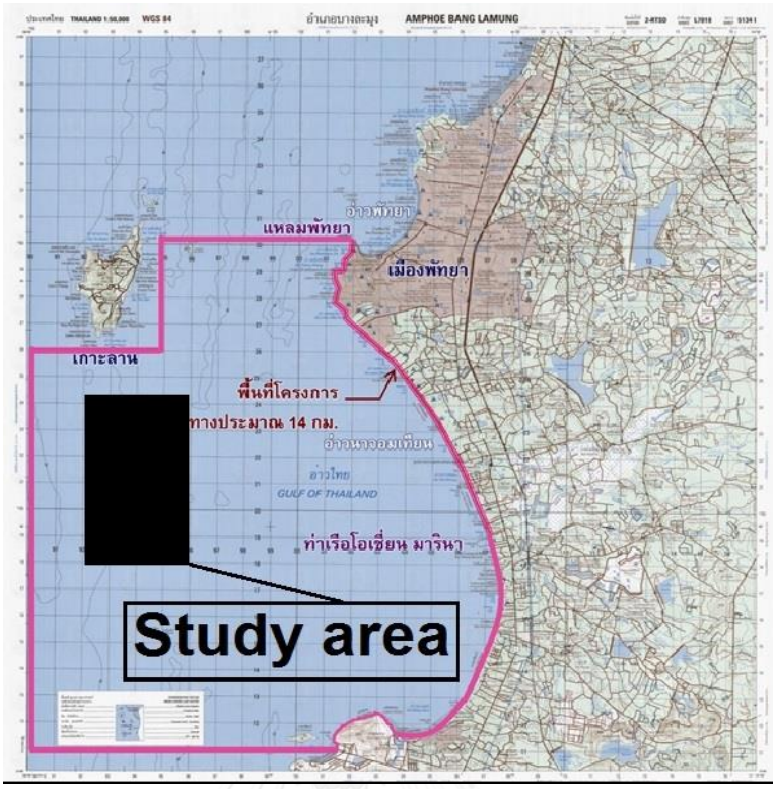


Figure 1 Study area

1.4 The result is expected to be received

1.4.1 To get the special information from the sand area of in the Jomtien beach offshore area of changwat, Chonburi.

1.4.2 To arrange stratigraphy of the sand dregs and to estimate the quality of primary sand are from definition highly wave movement around outside the Jomtien beaches.

1.5 Method of study (Fig.2)

1. Studying important problems.
2. Searching the information and theory that involve with the problems
3. Survey on the beaches.
4. Evaluation and data enhancement.
5. Given meaning to arrange the sediment of sand area and assessed potential to the sand.
6. Discussion and conclusion of studying to do thesis.

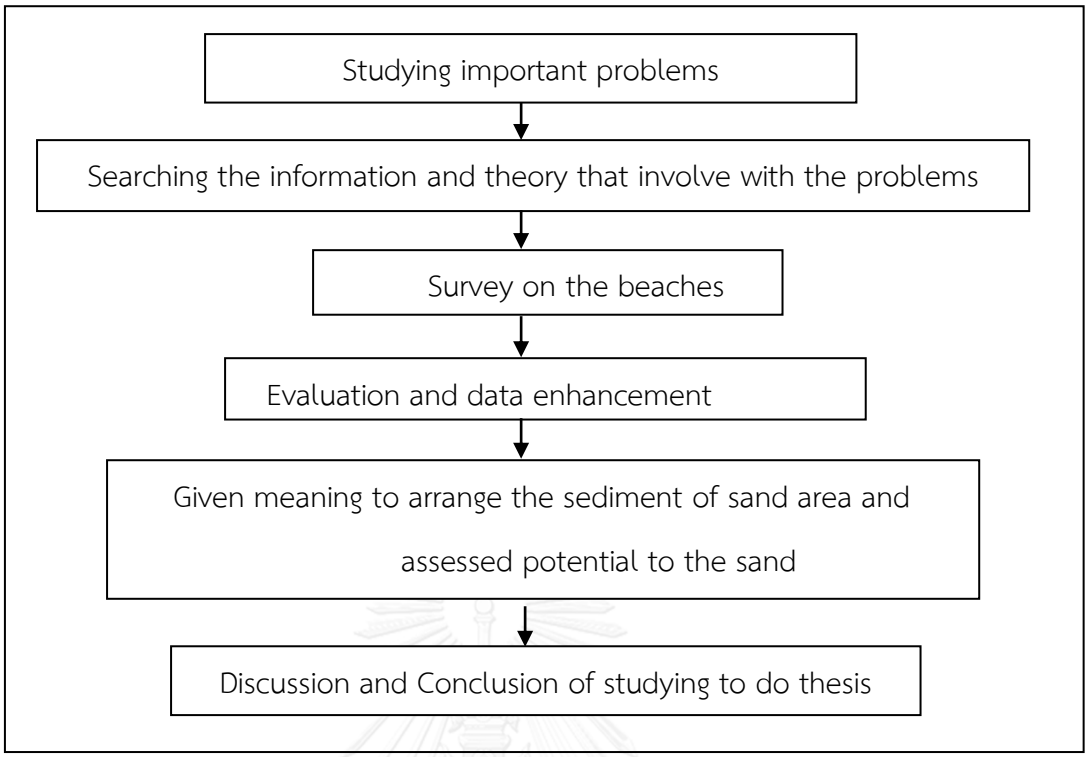


Figure 2 The process of research

CHAPTER 2

Literature reviews

2.1 Coastal erosion of Chonburi province.

2.1.1 Coastal erosion

The northern part of the gulf of Thailand has been studied in offshore Jomtien beach has been eroded an average 1 – 5 m. per year (Department of marine and coastal resource, 2013). There are 5 erosion areas that combine with

1. Naklau market beach in Banglamung district
2. Bannammoa - Najomthong beach in Pattaya district
3. Pak Klong Ban Amphoe shore in Pattaya municipal area
4. Bang Phra shore in Sri Ra Cha-Mueang Chonburi district
5. Udom bay in Sri Ra cha district

The erosion studies that were analyzed are in Bannammoa- Najomtien beach at Pattaya municipal area which started from Laem Mai Ruak to Ban Hin Wong about 8 kilometers long and 300-500 meters wide. In this place, there is coastal erosion around the south of beach that was surrounded by roads and breakwaters. The erosion distance is close to 3 kilometers, but it is in a rank about 2 meters per year (Sinsakul et al., 2002)

Here is unstable erosion that many years gather sediment in short time as well as it is up to shore's current. Causes are from changing of temperature more than human activities that had affected to change of wind speed to the shore (Thammasat University Research and Consultancy Institute, 2006).

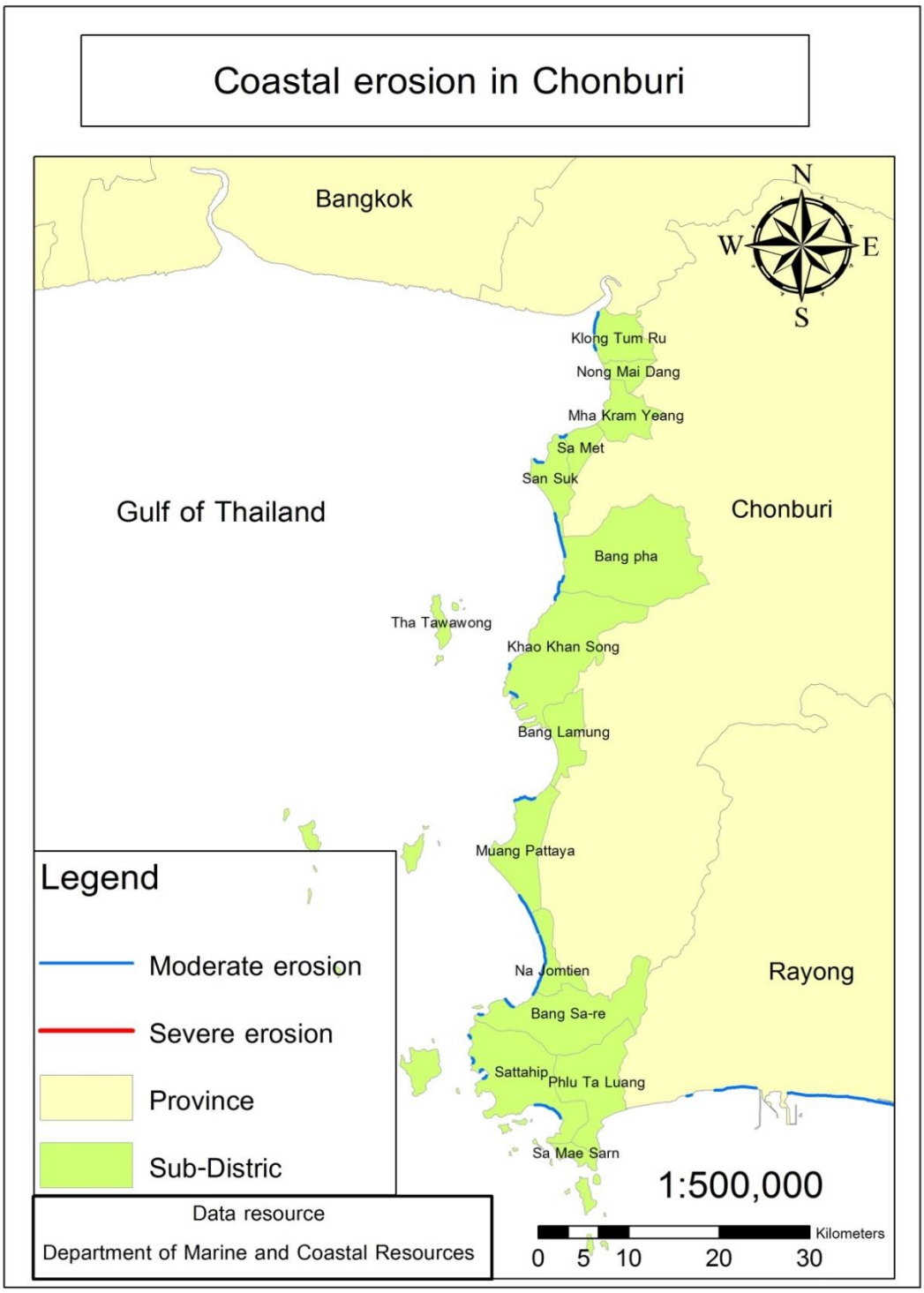


Figure 3 Coastal erosion's situation at Chonburi.

Province	District	Sub District	Erosion Area (Rai)				
			1952 - 1974	1974 - 1990	1990 - 1999	1999 - 2002	2002 - 2008
Chonburi	Mueang Chonburi	Khlong Tamru	- 8.36	- 3.99	- 36.13	- 38.97	- 40.72
		Nong Mai Daeng	0	0	0	0	0
		Bang Sai	0	0	0	0	0
		Ban Khot	0	0	0	0	0
		Makham Yong	0	0	0	0	0
		Bang Pla Soi	0	0	0	0	0
		Ban Suan	0	0	0	0	0
		Samet	0	0	0	- 7.21	0
		Ang Sila	- 2.82	0	0	0	0
		Saen Suk	- 10.03	- 9.98	- 21.41	- 0.69	- 15.68
	Si Racha	Bang Phra	0	0	- 1.80	0	0
		Si Racha	0	0	0	0	0
		Surasak	0	0	0	0	0
		Laem Chabang	0	- 1.36	- 3.42	0	- 4.17
	Bang Lamung	Bang Lamung	0	0	0	0	0
		Na Kluea	0	0	- 9.78	0	- 6.98
		Pattaya	0	0	- 5.69	0	- 3.84
		Na Chom Thian	- 4.56	- 0.74	- 32.65	0	- 36.90
	Sattahip	Bang sare	- 2.04	0	- 5.44	0	- 1.34
		Sattahip	- 11.69	0	- 12.15	0	- 7.15
		Samaesan	0	0	0	0	0
		Phlu Ta Luang	- 21.33	0	0	0	0

Table 1 Detail of a shoreline faced up with erosion problems in Chonburi.

(Aquatic Resources Research, 2011a)

2.1.2 Survey of an erosion problem

Jomtien beach is a tourist attraction which is a good place for Thai and foreigner tourists to rest in Chonburi province because the beach is beautiful and near to Bangkok. Besides, there is Pattaya tourist travelling here since Jomtien is more peaceful than other beaches and readier about essential structures. At present, the survey found that the beach was decadent because facing the erosion problems that cause both natural and human activities at the coast as other coasts in Thailand.

Coastal erosion at Jomtien beach is a severe trouble that has been occurred since 1990 there are no any policies to solve successfully. There is a specific place at Ban Nam Mao which experiences the big problem (Aquatic Resources Research, 2011a).

2.1.3 How to the problems in the past

Solving the coastal erosion problems in the past are different ways that each ways has also different results. The ways to solve are T-Groins (collecting stones to jut in the sea for holding the sediment) in **figure 4** that it can protect to this extent, but it causes to the coastal erosion in the North, Riprap Seawall (Placing on the top around the beach like a dame to impact force of the sea) in **figure 5** that it can cause the erosion's problem too, and Sand Bags **(Fig.6)**. Every ways to solve the problems is only for facing problems, however they cannot solve the problems for long-term. In the result, the coastal erosion's problems have occurred continually (Bennui et al., 2008).

Figure 4 T-Groins in Chalatat beach, Songkhla

(Bennui et al., 2008).

Figure 5 Riprap Seawalls in Chalatat beach, Songkhla

(Bennui et al., 2008).

Figure 6 Sand Bags Sai Kaew beach, Songkhla

(Bennui et al., 2008).

2.1.4 Jomtian area in the present (survey of coastal erosion)

Aquatic Resources Research Institute, Chulalongkorn University, has collected a problem data in the past since 2010 - 2013, and the research project that had been done on February 5-6, 2015 has surveyed the coastal erosion area. The shore area in the project is long about 13.4 kilometers. The surveyed result of the coast is as per below **(Fig.7).**

Surveyed area part 1, it starts from the west of Balihai bay to underwater rocks that the shore is about 3.3 kilometers width. The coast beach is the rocks and arc from each survey of the bay beaches which have balanced following the influences of the rock. The coast is about 15-30 meters width.

Surveyed area part 2, it starts from the underwater rocks to Tappaya road area that the shore is long about 1.1 kilometers. The beach has in good condition, and it is around 15-20 meters width. There are trees along the beach.

Surveyed area part 3, sea coast is long about 4.3 kilometers. This area has Thai and foreigner tourists who have traveled along the beach. There are the big trees along the shore. In the north, state of the beach is around 20-30 meters width. Width of the beach is slowly narrower, and the narrowest is about 5 meters.

Surveyed area part 4, there is long about 1.0 kilometers. From the survey of the beach area, there is building rock wall to protect river bank, and there is a concrete wall on the back along the way. Beach's width area in the front of the rock wall to protect river bank is too much narrow. There is about 5 -10 meters width from the beach to be narrower until the end of the beach.

Surveyed area part, 5 the beach is long about 600 meters. Around beach is a private place, and there is no service on the beach.

Surveyed area part 6, the beach is long around 3 kilometers. The beach area is the white beach almost along the way. Beach's width is about 10 -15 meters width.

To sum up, the most area of Jomtien beach is seriously facing the coastal erosion problems **(Fig.8)** that had affected to an economic system and being life of people in this area. This is necessary to solve urgently.

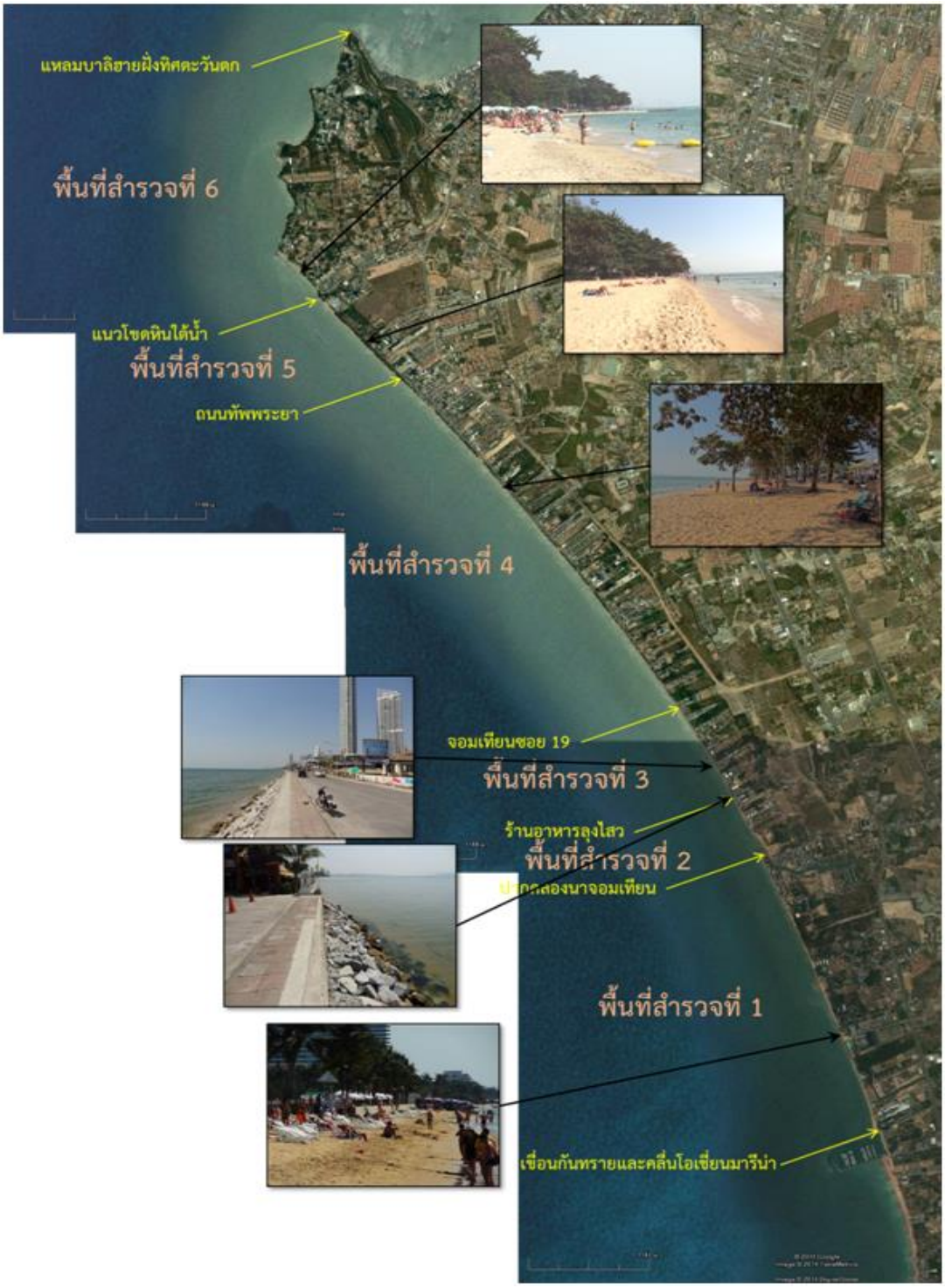


Figure 7 Problem of Jomtien beach in the present

(Aquatic Resources Research, 2011a)

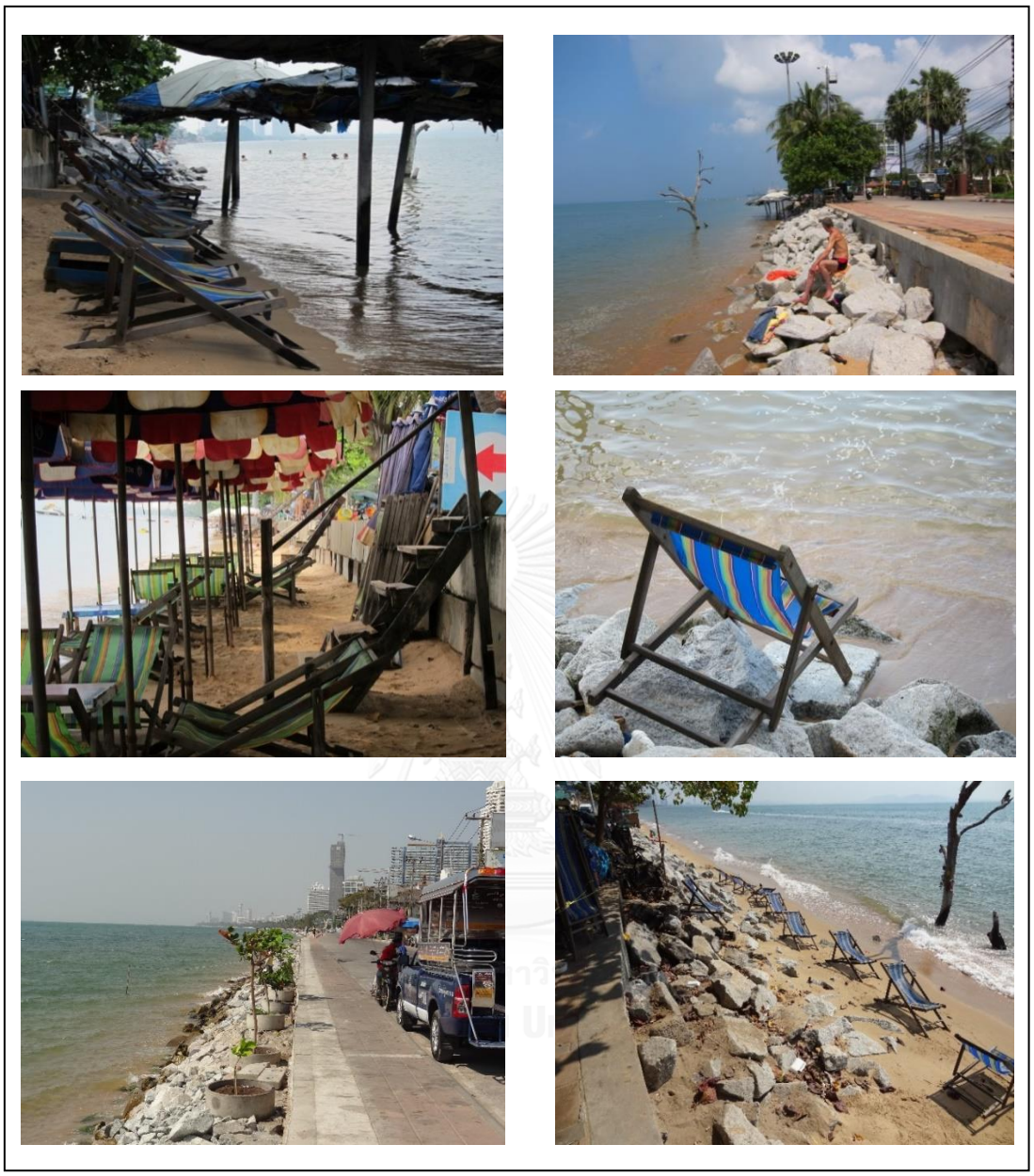


Figure 8 Coastal erosion problems and using service of the tourist in the present (5 – 6 February 2015)

2.2 Beach nourishment

How to protect and solve the problems of coastal erosion have 4 ways that are 1) Ignorance, 2) To move a place, 3) To make a stability of the coast with a hard structure, 4) To make a stability of the coast without the hard structure (Aquatic Resources Research, 2015). For making a stability of the coastline with a rigid structure, the important form is the beach nourishment that is taking sand from other places to nourish the erosion place. Beach nourishment is an improvement of the coastal erosion beach to be increasingly better than other forms (Godfrey, 2014). Solving problems with beach nourishment is necessary to nourish for each proper time, furthermore it differs for each places.

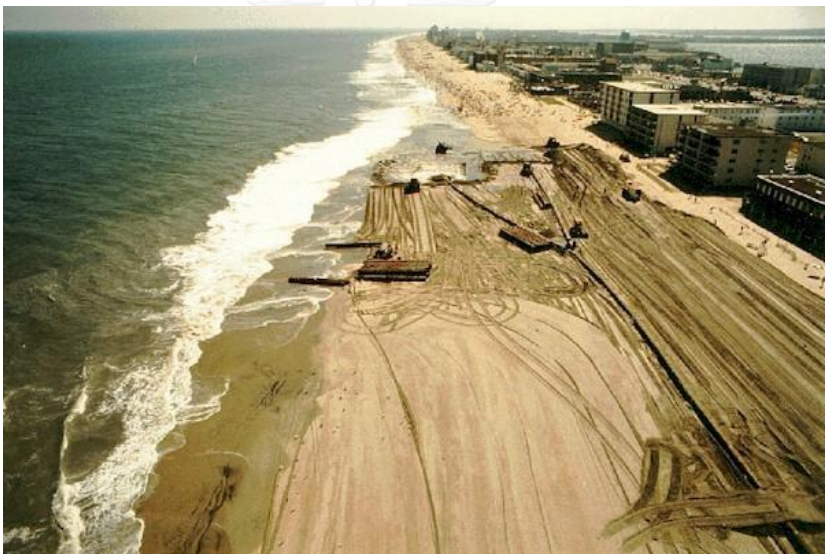


Figure 9 Beach nourishment

(Godfrey, 2014)

Beach nourishment or beach renovation with taking sand from other places to add the beach in another place help improving erosion of coastal beach to be better, moreover it helps to protect a building or construction on the coastal erosion beach in a short time (Pilkey and Hume, 2001). The beach nourishment has to do many times in proper time but different places (Pilkey and Dixon, 1996). After the beach nourishment has finished, it has to follow up and verify the beach intermittently to decide and plan in repaired the beach and being as the plan.

Advantage	Disadvantage
• Beach nourishment can help to have naturals' stability to be the beautiful beach, and this way does not have a structure that is disturbed our scenery. • This way can spread more the land to be useful, so this is especially to tourism. • It can help to protect buildings which face the erosion's problems. • Beach nourishment is a way that is well-known for making stability, and it has no any pack a punch.	• Beach nourishment is the way of changing the beach ecology. • It cannot stop erosion that has happened until now. When the storm faces the shore beach, it has to nourish sand many times in a proper time. • This is an unstable structure to do. It has to do many times, and it combines the factors of sand's geography and price.

Table 2 Beach nourishment has advantages and disadvantages

(Pilkey and Hume, 2001)

Figure 10 Before and after of beach nourishment at Miami beach

(Valverde, 2014)

Beach replenishment or beach nourishment is taking the sand from other places to fill in on erosion and sand damaged beaches. This way can help adjust and restore the erosion beaches to be better, moreover it can protect the building which stays around the beach to reduce erosion in the short time, and the beaches have still been naturally (Pilkey and Dixon, 1996). In the **figure 10**, beach replenishment continues to do many times following opportunity and the difference of places (Pilkey and Dixon, 1996). After beach replenishment or beach nourishment had finished, it is necessary to follow for inspections continuously by coastal profile which is for calculated the sand erosion, and decided whether to adjust time to replenishment, to prepare sand quantity, to follow the plan (Department of marine and coastal resource, 2013). Sometime, this way can call "beach (re) nourishment" (Pilkey and Dixon, 1996).

In the early process, beach nourishment has to replenish on the beach wider than the early plan since the beach nourishment has still had the erosion as the beach before. The beaches have usually loosen some sand, so it has to nourish again. Not only beach nourishment is an unstable way to replenish, but also maybe it doesn't be success or inefficiency in some places or environment. Sand for nourishment can damage during the short time (Pilkey and Dixon, 1996) and it is a high investment when it compares with making headland.

Nowadays, the most potential sand resources are under the sea because sand resources have a quality, little contaminant in the pollution, and worthiness more than other resources. For searching the sand resources in the sea, it has to seismic survey. How to survey combined with echo-sounder to survey the sea deep, and the sea geography by shallow seismic reflection profiling. There is a profile record of shallow seismic reflection profiling to find dregs' types, trick and also depth and types of shale for carrying sand deposit. Shallow seismic reflection profiling is how to survey with seismic reflection which sends waves into the underwater trough intermediary and layers of soil or stone, after that it can get turning back of signal to evaluate and translate the meaning (Aquatic Resources Research, 2011a).

2.3 Geological structure

Surveys' data of geophysics and exploration drilling is for finding petroleum sources and natural gas in the gulf of Thailand to identify geology structure which is for basement in the Quaternary. This area is a graben basin that is from subsidence of fault-block basin in Tertiary period. Shale basement in Tertiary and Cretaceous combines with mudstone, siltstone, sandstone, conglomerate and igneous rock (Pradidtan and Dook, 1992; Srikulwongse and Jarusirisawadi, 1990).

From the study of geology map, scale 1:250,000, Department of Mineral Resources since 2011 found that the character of geology in the study area combines with sediment in Quaternary, Carboniferous, and Ordovician. They have some detail as per below.

1. Sediment in Quaternary combines with gravel and clay that the sediment is not harden from the cumulative flat river, channel, delta and terrace. The sediment in Quaternary can separate with 2 types that are

1.1 Alluvium, valleyfill and river, [Qa] combine with plain sediment deposition by water, gravel, sand, raceway sediment and floodplain that they can find coastal plain at Jomtien beach such as gravel, siltstones, clay and laterite soil.

1.2 High and low terrace deposit, [Qt] mixed with sediment, sand and soil that are from settled sediment, old channel and Foothill sediment at high from the plain about 15-90 meters.

2. Carboniferous Granite, [Cgr] is an igneous rock in Carboniferous that could find Pattaya cape. The east of Pattaya is a horizon along Sukhumvit road.

3. Thung song formation, [O] is the stones in Ordovician mixed up a lot of limestone which is quite hard gray until black, furthermore there are many stones examples shale, sandstones, phyllite stone, quartzite, calc-silicate rock and slate that were founded the mountain east at Jomtien beach (Sinsakul, 2000).

2.3.1 Marine geology at Jomtien beach

From the data about the deep sediment offshore at Jomtien beach eco-sounding is a process to record Shallow marine seismic reflection and sediment sampling (Department of Mineral Resources, 2011). In this route survey, it passes in the sheet 5134 I through Bang Lamung district, Chonburi. In conclusion, geology represents how thick of Holocene sediment map.

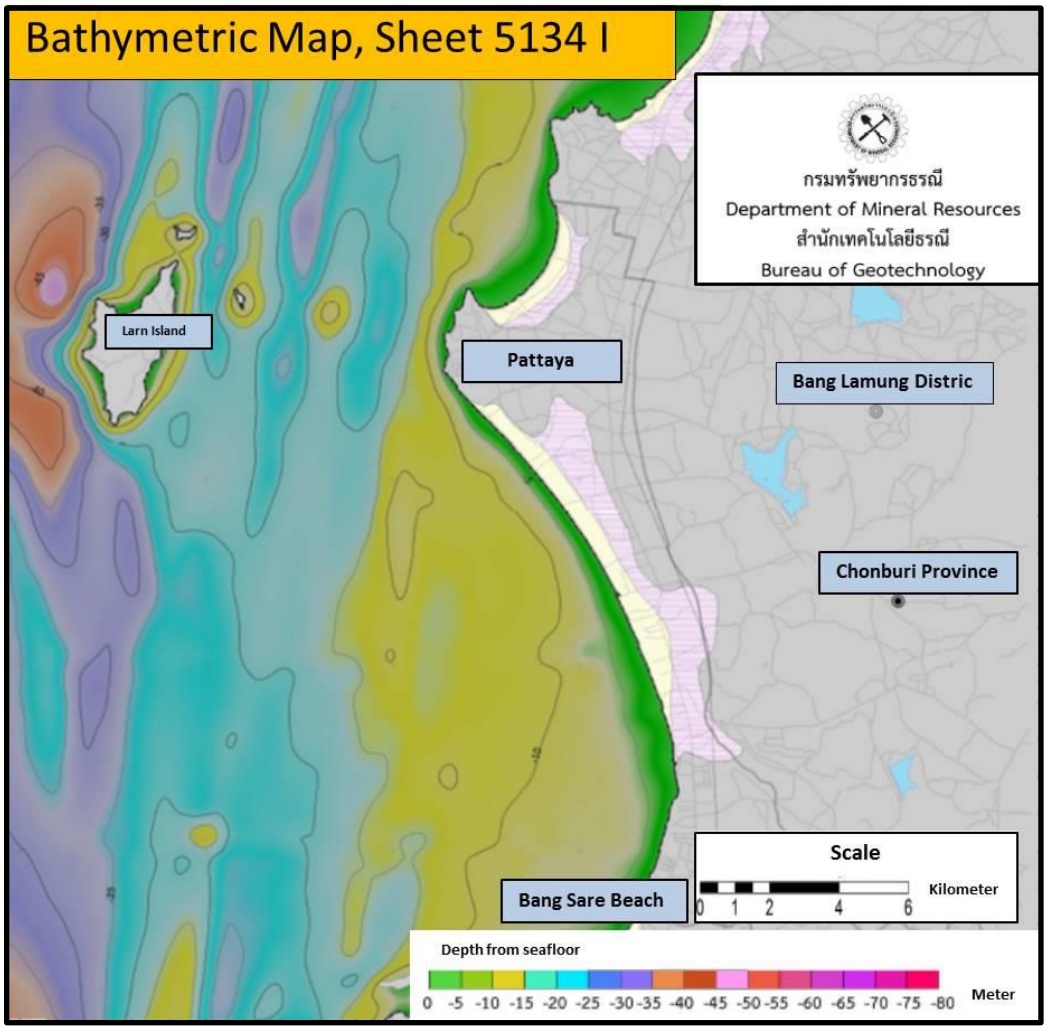


Figure 11 Sediment setting the Holocene in offshore Jomtien beach

(Department of Mineral Resources, 2011)

In the result of seismic survey in the **figure 11**, there is a characteristic of dune on the sea floor. There is marine mud and sandy mud with shell fossils which distribute around the survey place in the north offshore of Pattaya bay.

Besides, sand dune is at Jomtien offshore. The characteristic of seafloor sediment compose of 2 forms which are lower and upper platforms. The lower platform that the sediment was piled in the late Pleistocene is period in the land environment is deep in lower mean sea level -2 up to -46 meters. The upper platform that sets in the Holocene with the influence of risen sea since 1,000 years ago is thick from the seafloor 0 - 15 meters. Sand dune has been found at Pattaya offshore which was classified in the upper platform since Holocene until now.

2.3.2 The study of the layer sediment by well logging

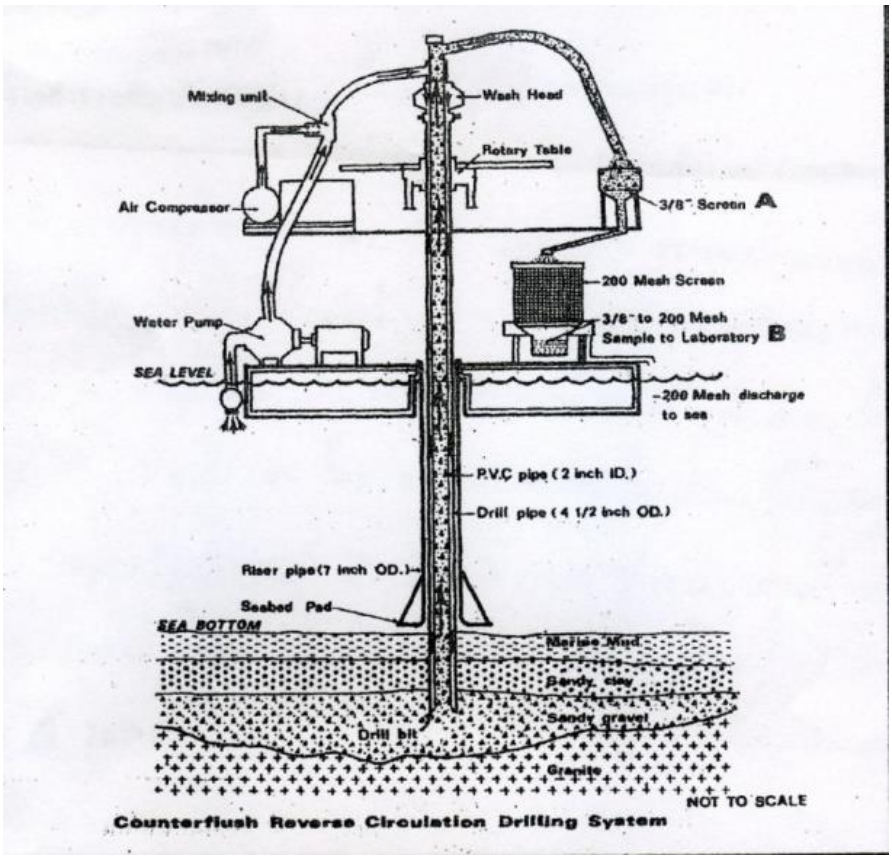


Figure 12 Counterflush Reverse Circulation

(Department of Mineral Resources, 2011)

The survey by shallow seismic reflection profiling discovered dune in Holocene around Jomtien offshore. Exploration drilling counter flush reverse circulation **(Fig.12)** which corrected through a gap between pit wall and taken back dirt drill string to the top with high-pressure pumps is how to survey. A large sediment would precipitate to a clarifier, in the contrary small sediment would flux to a bottom hole and it was pumped again and again. The large sediment was pumped together with muddy water by a suction power. It used motoring cathead to note a standard penetration test in field log note for testing the settle distribution.

2.3.3 Quaternary geology

The Aspromonte, a mountain massif in Italy, is unconformable covered local by middle-upper Miocene to Pleistocene sedimentary sequences (Bonardi et al., 2001). Paleo - Quaternary extensional basins formed in the Milazzo onshore are filled with a variety of sediments which mostly comprise gravels, calcarenites and bioclastic sands, clayey, marls and marling limestone.

Data seismic survey of exploration drilling to find petroleum and natural gas sources is in the gulf of Thailand (Srikulwongse and Jarusirisawadi, 1990), and (Pradidtan and Dook, 1992). The gulf of Thailand and Chaophaya lowlands were covered with many sequences of fluvial deposits and marine sediment. From (Pradidtan and Dook, 1992), indicate that an amount of settle which is thick about 1,000 – 1,700 m. in the gulf of Thailand is accumulated since the Quaternary. Types or characteristics of the set are similar with Chaophaya lower lowlands (Jarupongsakul and Kaida, 2000). In the middle gulf of Thailand is slowly continuous subsidence until Cenozoic. In the area around the shore of Thailand's gulf, the sediment would be thick less than in the middle and subside rate would happen too slowly (Roy, 1994).

Nowadays, coastal geomorphology of the gulf of Thailand has had an origin and evolution in the Quaternary time (Jarupongsakul and Kaida, 2000). They can separate to be two periods which is Pliocene (18,000 – 10,000 years ago) and Holocene (from 10,000 years to nowadays). In the result of changing of periods, the coast has been changed by global environment which is especial climate changes that it affects to sea level rise many times. During the early Pliocene, the study found that the expanded gulf of Thailand has no the salt water to land. The settle is from cumulativeness of channel and onshore. After 30,000 years ago, the sea level in the gulf of Thailand has still decreased. This caused to connect a land under the sea with Java islands and Kalimantan which was called Sunda shelf (Hanebuth et al., 2000). In the **figure 13**, it shows accumulation of grit and clay which was from the channel. The different characteristics of the shore and the gulf area of Thailand have been a land around 10,000 years ago until the end in Ice age. The ice had melted to the ocean. Around the world, the sea phenomenon had been rising. The sea level in the gulf of Thailand would be higher and higher as 1,000 years ago (Sinsakul, 1992; Sinsakul, 2000).

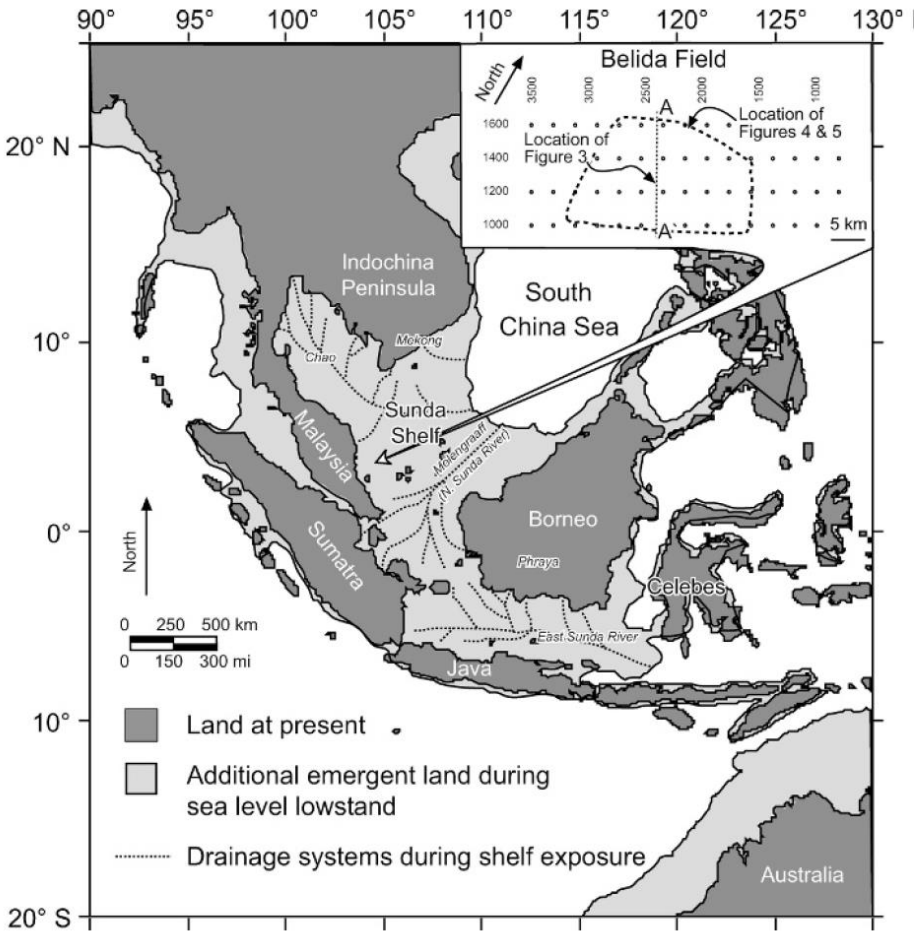


Figure 13 Channel's flowing through in the gulf of Thailand.

(Hanebuth et al., 2000)

2.3.4 Sea levels' changing in the late Quaternary

The sea levels worldwide have been rising to the highest +5 meters during 125,000 years ago, after that the changing of sea levels has ebbed or increased intermittently but not up to be higher than nowadays. Until late Pleistocene or Ice age about 10,000 years ago, the sea level has the lowest about 80 -100 meters compared with the sea level now **(Fig.14)**. After the sea level is up to high fast because of the polar ice's melting, the polar ice melt down and flood to the basin of the gulf of Thailand in the present (Evans et al., 1995).

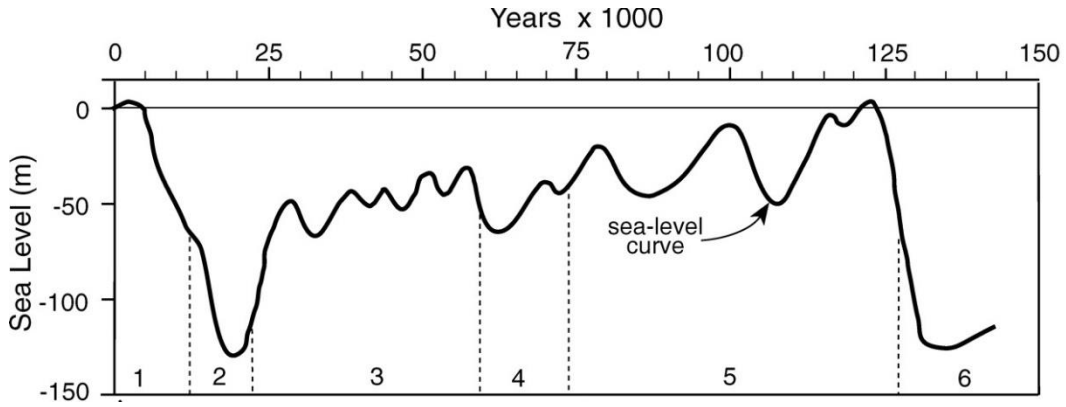


Figure 14 Sea level changes' in the late Quaternary

(Rivers et al., 2007)

From the study of the sea level earth changes' characteristic in the late Quaternary (10,000 years until now) in Malacca strait area (Geyh et al., 1979) (Sinsakul, 1992; Sinsakul, 2000), they found that sea rate of transgression about 2 cm. per year. Until 4,000 - 6,000 years ago rising sea is up to maximum around +5 m., it encroached to flood from the lower central plains Ayutthaya province. After the rising sea, it decreased slowly to the present sea level (Sinsakul, 2000).

2.3.5 The result of an analyzed and interpreted data with marine seismic

From the result of an analyzed and interpreted sediment data for shallow seismic reflection profile with high resolution, this was found sediment characteristics under the sea floor's survey area. Classifications have two types which are lower sequence and upper sequence. Besides, there is shale layer's characteristic around the north of survey area.

Lower sequence is the survey route which is from the sea level -1 to -25 meters. There is a trail of erosion demolished to be big channel in the north and south. Only in the south of the survey area has no kept on the ancient channel by coastal sea in the present.

Upper sequence is from cumulative of the sea influence for early Holocene until now. There is thick from 0 to 17 m. in a shale area which leans out of seafloor on the south area of old channel (Somboon and Thiramongkol, 1992).

Result from data interpretation in the survey area can compare with seismic profile and exploratory drilling. Moreover, a sample sediment study in many places of Thailand's gulf (Roy, 1994) was found this upper sequence consists of clay layers. These clay layers are amber with hazel, and orange as well as red mottles on the soil. Sometimes, there is iron ore or manganese inside the soil. In addition, the red earth layer and laterite were founded because of oxidization on some layers of sediment. All evidences can identify the lower sequence's surface. That has ever touched the temperature too long time before sea settle in Holocene period closed on. It is unconformity of accumulation discontinuous between Pliocene and Holocene period (Sinsakul, 2000).

Marine sediment in the gulf of Thailand can take to beach nourishment. It can classify 2 big types that are upper sequence and lower sequence. In general, it can be found the dune accumulated outside offshore which is deep from sea floor about 15 meters. The sediment is in Holocene period. The upper sequence is deep about 10 - 46 meters. The lower sequence quite is the settle from old channel during the Pliocene. The data that was carefully brought to interpret one more time grades the character as well as a sequence of sedimentary layers. These were found clearly sequence of data's identity to present seismic reflection (Aquatic Resources Research, 2011a).

There are analyzed that an amount of lower sequence was accumulated sediment layers with the influence of the canal during the late Pliocene. Several of complexed seismic facies in the sedimentary series identify the state of weathering and incrimination many times because of the sea levels changing. (Evans et al., 1995; Ringis, 1986; Roy, 1994)

To identified that the upper sequence is accumulated sediment layers from the early Holocene. There is thick about 0 - 20 meters. The sea was rise rapidly in early Holocene period, so it causes accumulated of sandy grey clay with shells and humus portion which cover along channel in Lagoon type estuaries. Sea level rise can causes erosion on lower sequence surface and the creation of sedimentary layers to be assumed paleo beach. Size and quality of the creation of sedimentary layers is up to the quantity of ancient sediment nearby. Normally, there is too thick

around Mae Klong, Thachin, Chao Phraya and Bang Pakong river (Roy, 1994; Tanabe et al., 2003). However, the river would be narrow when it takes away from the coast about 10 - 15 kilometers. The upper sequence has a less thickness (average 3 m.) since the main rivers don't bring the sediment to the sea.

2.3.6 Sediments in offshore Jomtien beach

1) Feature of coastal sediment transport

Most of sediment transport in coastal sediments is an origin from a land that particle was taken and let to the seafloor with different sedimentation rate **(Fig.15)**. The deposit on the sea floor can identify background of former environment such as date of event; Tsunami, year of the flood, the thick of the sediment in that year or identified the former sea background. Movement of the offshore sediment started from the origin of sediment which composes of weathering stone and soil. Natural processes become erosion particle which transports along the river. When the particle was taken to estuary, the speed of the tides is slowly settled. It had long term considerated after sediment post-settling had re-suspension. It would have happened from the influence of tides and wind. If the influence of tides and wind had had a little sediment, the compaction would take place vertical or horizontal sedimentation, land formation. Conclusion, it shows that an average precipitate blows far away (Pradit, 2012). These characteristics of sand sediment follow the current, but the harder sediment would move on the sea. The process happened around the offshore, however the most of process often starts surf zone which has turbulence and powerful tides.

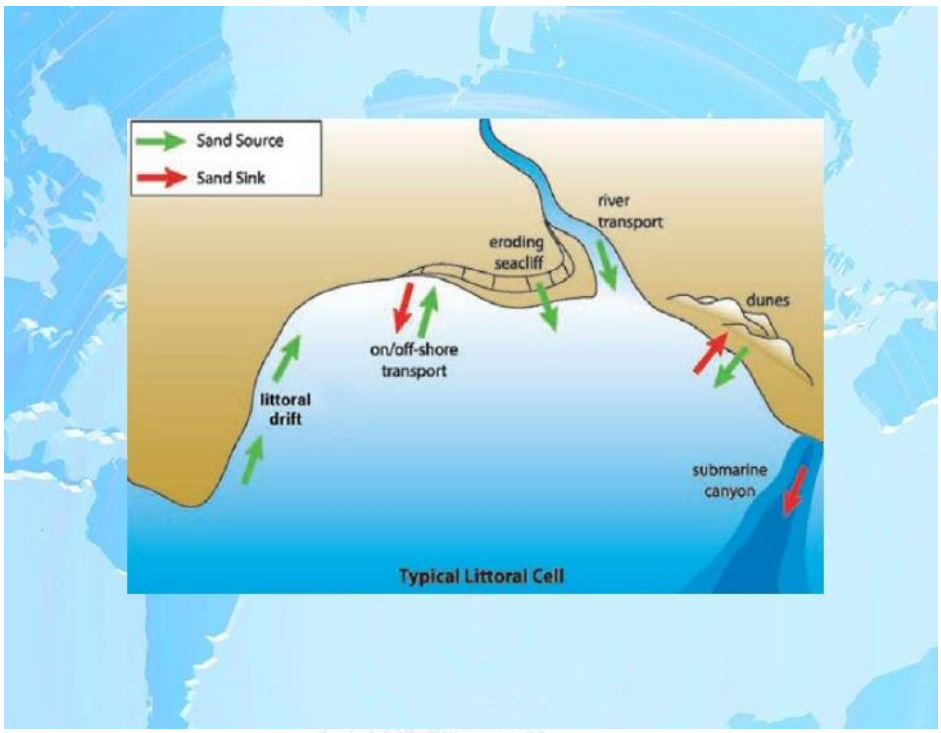


Figure 15 Coastal sediment transport

(Foster, 2010)

2) Basic sedimentology

Settle consist of any particle from gravel to fine sand. Rough settle group is from a fracture of minerals and stones. Thorough settle group is example as clay which is from weathering of new mineralization called secondary mineralization. Secondary mineralization has been small and Alluvium in silicate surface structure of system. In general, classification of grain size particle often uses whenworth scale. There are some details as per below in the **table 3.**

Settle has an element with different sizes, so it has a lot of different names and forms. All forms are named to depend on an amount of particle proportion which is sand, silt and clay **(Fig.16)**.

Grain Size	Size (millimeter)
ravel	>2
Coarse sand	2-1/2
Medium sand	1/2-1/4
Fine sand	1/4-1/16
Silt	1/16-1/256
Clay	<1/256

Table 3 Wentworth scale

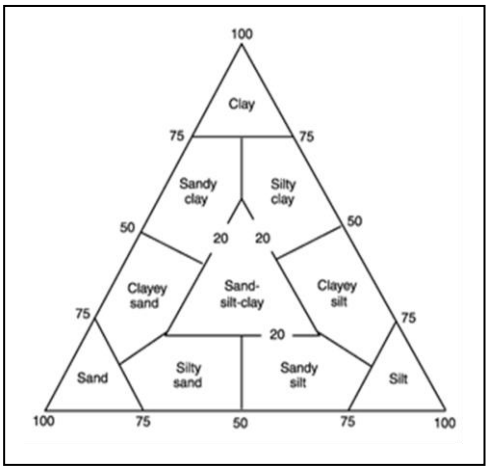


Figure 16 Proportion distribution character of sediments

(Wentworth, 1922)

Sea sediment to feature in the study area can conclude as follows.

The characters of sea sediment in lower gulf of Thailand have mean of sand, silt and clay particle as 32.4%, 28.1% and 39.5% respectively (Bua-ngam, 2013). Marine sediment in lower gulf of Thailand has more powdered than the sediment in the middle gulf of Thailand as the **figure 17 - 18**. From the consideration of the sediment distribution, it is in study area which refers sampling points near the study area (Bua-ngam, 2013). **The table 4** found that the sea sediment is around Jomtien offshore which is sand, silt and clay subsequently.

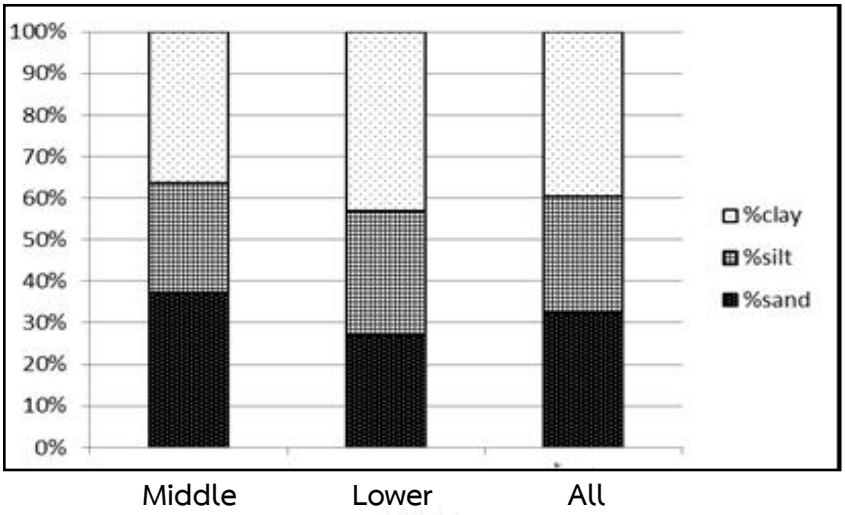


Figure 17 The proportion of sediment size on surface in gulf of Thailand

(Bua-ngam, 2013)

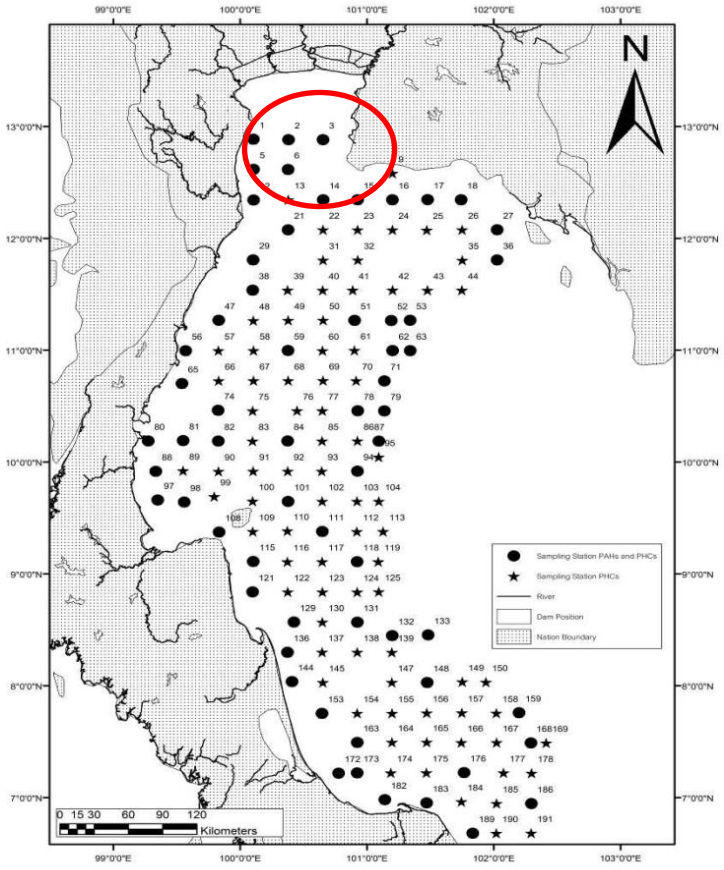


Figure 18 The place of samples in the gulf of Thailand

(Bua-ngam, 2013)

station	Proportion (%)			Sediment name
	Clay	Silt	Sand	
1	6.62	13.2	80.2	Sand
2	3.18	15.7	81.1	Sand
3	22.4	24.0	53.6	Sand silt clay
5	36.2	23.5	40.4	Sand silt clay
6	18.8	13.0	68.2	Clayey sand
7	30.7	23.1	46.2	Sand silt clay
8	3.18	15.7	81.1	Sand

Remark Jomtien offshore

Table 4 The sediment size and types on the top of an study area

(Bua-ngam, 2013)

They are classifies the types of sediment consisted of 6 types; silt, sandy silt, silty sand, sand, sandy mud and mud on surface in the gulf of Thailand **(table 4)**. The sediment characters a large particle such as sand and silty sand which expand mostly in the upper area and the west in the gulf of Thailand **(Fig.19)**. (Shi et al., 2014)

The characters of sediment have small particle, for instance, silt would distribute in the middle of the gulf of Thailand **(Fig.20)**. Firstly, distribution of silt in studied area (**Fig.21**) was found that the characteristic has been smaller than other areas (green shows the lowest silt area). And then, distribution of clay in studied area (**Fig.22**) has been the lowest clay (dark green shows the quantity of clay 0-8%). In the last point, distribution of sediment in studied area (**Fig.23**) has almost been sand (80-90%) that distributes massively around Jomtien beach, Chonburi (Dark orange).

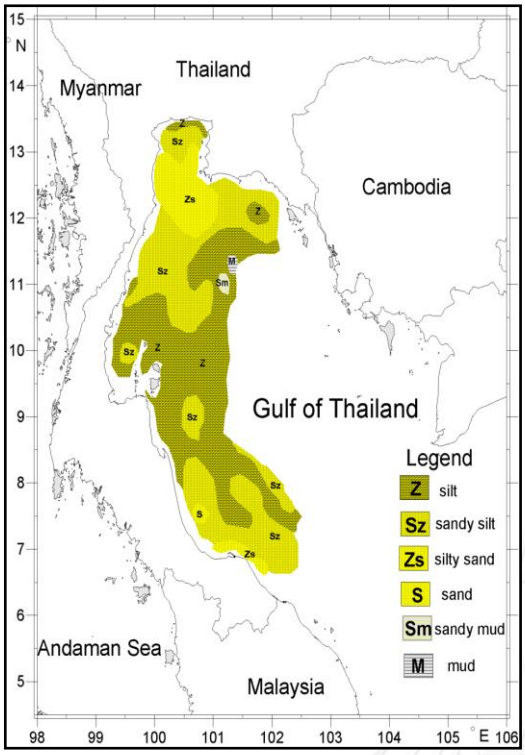


Figure 19 Distribution of the sediment in the gulf of Thailand types

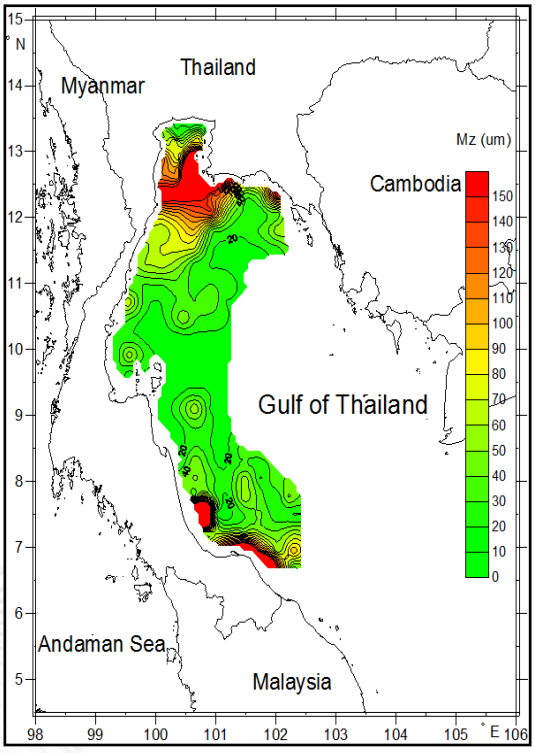


Figure 20 Distribution of the particle in the east of the gulf of Thailand

(Shi et al., 2014)

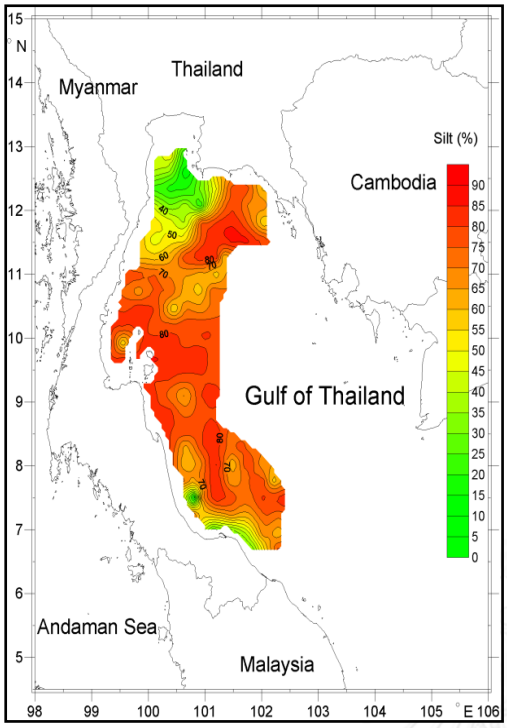


Figure 21 Distribution of silt in the gulf of Thailand

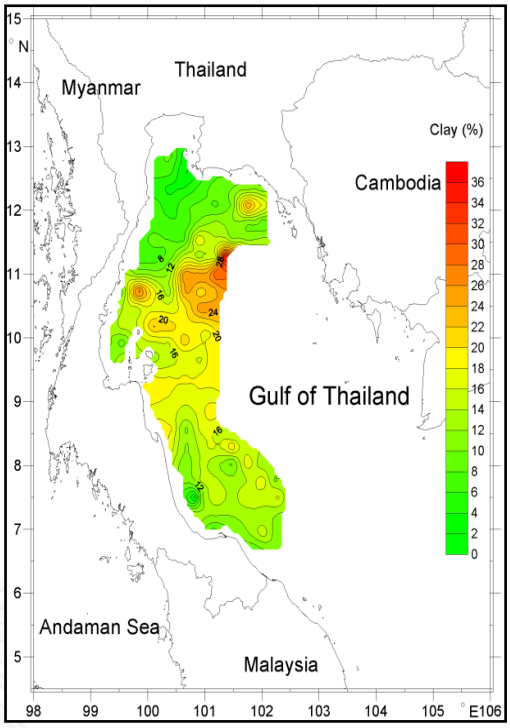


Figure 22 Distribution of clay in the gulf of Thailand

(Shi et al., 2014)

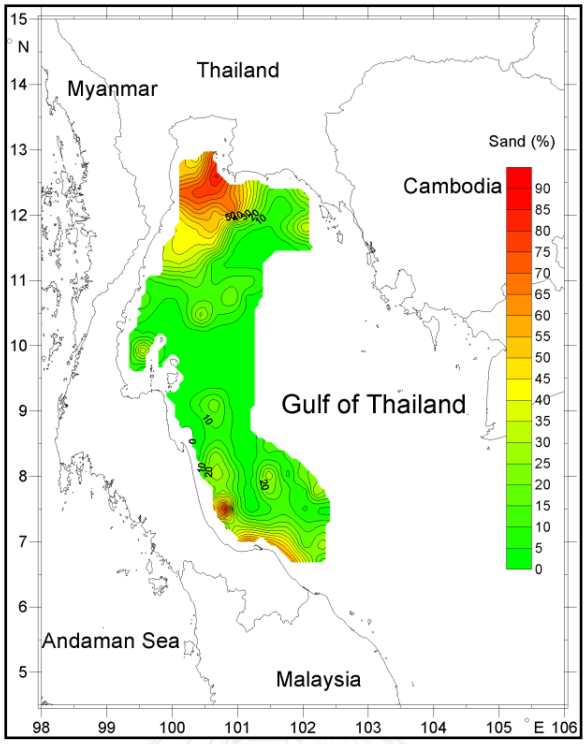


Figure 23 Distribution of the sand particle in the gulf of Thailand

(Shi et al., 2014)

2.4 Survey and data interpretation

2.4.1 The survey by shallow seismic reflection

Survey uses seismic survey for surveying sediment layer by high resolution shallow seismic reflection in the west area of Norway. The result of data interpretation presents the identity of the stratigraphic and sediment layers. They are from Hydrophone of high resolution shallow seismic reflection to the sea floor and data reflection to return to data logger. The data logger records data that the data characteristic is from the characteristic of wave which shows sorting detail of sediment and rock under seafloor. (Stoker et al., 1997)

Surveys by reflection seismic which is geology underground survey with property reflection of wave, when it was released to impact with a seam of intermediary acoustic impedance (multiple of wavelength and the density's medium). Wave would have a reflection up to surface after seismic wave has released by origin **(Fig.24)**. (Burger, 1992)

Seismic survey has been applied to use elastic wave property by seismic wave down to the underground. It passed through intermediary and joint of rock layer, then it was gotten the wave signal that return to processed and interpret (Satarugsa, 2007). The data would take to be classified information following the character of sediment or rock layer that were found.

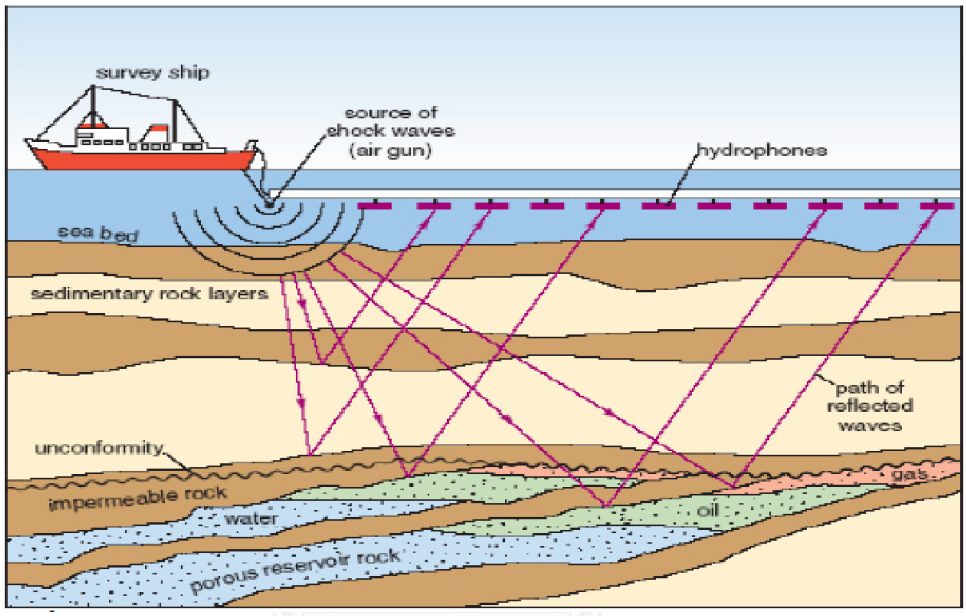


Figure 24 Working of reflection seismic

(Greene Jr and Richardson, 1988)

2.4.2 Seismic survey in offshore area

From seismic survey in offshore, Panama, Florida state USA, seismic survey and exploration drilling represents the characteristics of stratigraphic (Goff, 2014). The data of delta characteristics would be a sequence of discrete with the sediment on surface. Color of sediment estuary would be finer and brighter than other sediment layers **(Fig.25)**. Besides, the seismic data reflection has shown the character of old channel position. It is perpendicular and parallel to the coast that show the character of the sand sediment's motion in many directions in the past, deposition sequence and shape of old channel (Goff, 2014).

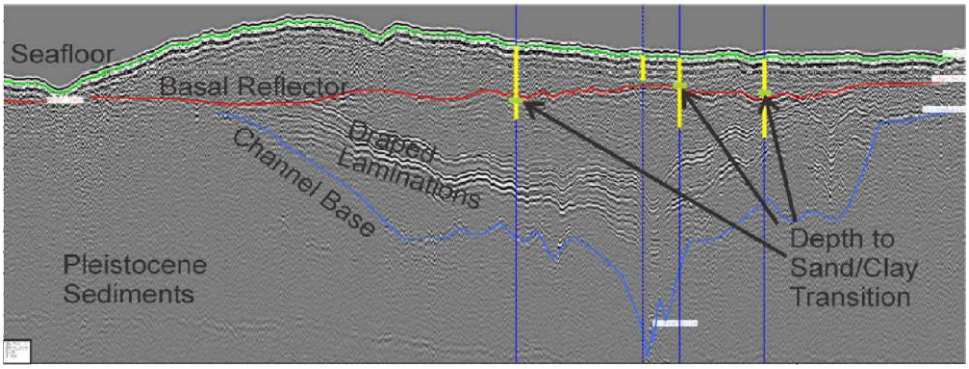
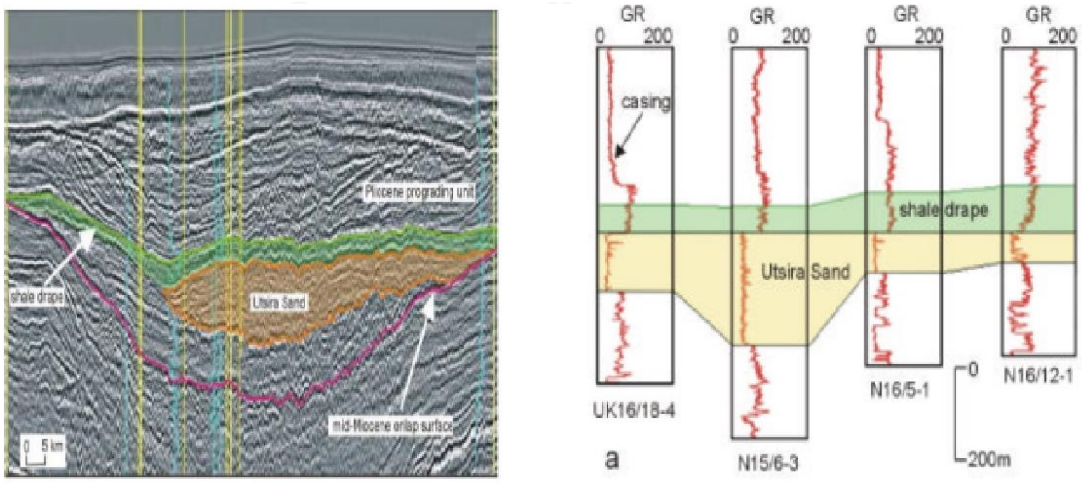


Figure 25 Separate the specific characters of seismic data

(Chadwick et al., 2004)

There are surveys for finding sand the offshore in Ustira, the North Sea can be whether carbon sequestration Pliocene. It was found the result of seismic data reflection **(Fig.26a)**. The differences of wave passed through an intermediary with different densities make to unconformity of data **(Fig.26b).** It shows the character sediment that shale closes on sand layers to be deep into the seafloor 20 m. during Pliocene. All can specify the character of sequence sediment on offshore. These methods are a primary of the survey before the thoroughly drilling exploration for reduced cost survey and increased accuracy more (Chadwick et al., 2004).



(a) Interpretation of seismic data (b) Unconformities of data

Figure 26 Separate the sand characters of seismic data

(Chadwick et al., 2004)

2.4.3 Interpretation and processing seismic data

Interpretation of seismic data is a layer selection which reflects seismic to compare seismic cross section with intersected route survey relation. There are many ways to find relationship between seismic data **(Fig.27)**. Unconformities can easily observe on seismic cross section. Long route survey can use to separate a general structure. Unconformity uses to identify sea-level changes which connect to geological time. The amount of data can indicate to chronological succession and depositional environment of any sediment types. In seismic cross section, it has waved velocity to pass through strata which can indicate both types and also origin of the strata (Sheriff and Geldart, 1983).

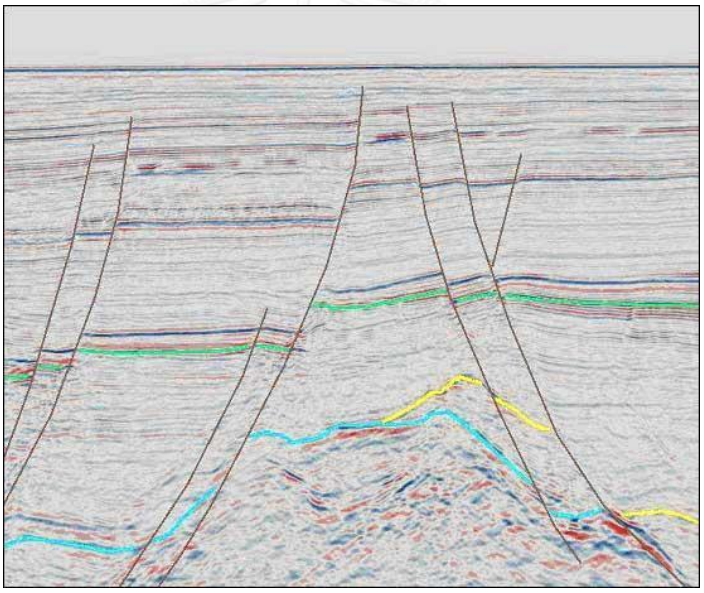


Figure 27 Unconformities of seismic data (Pattanee basin in gulf of Thailand)

(Department of Mineral Fuels, 2009)

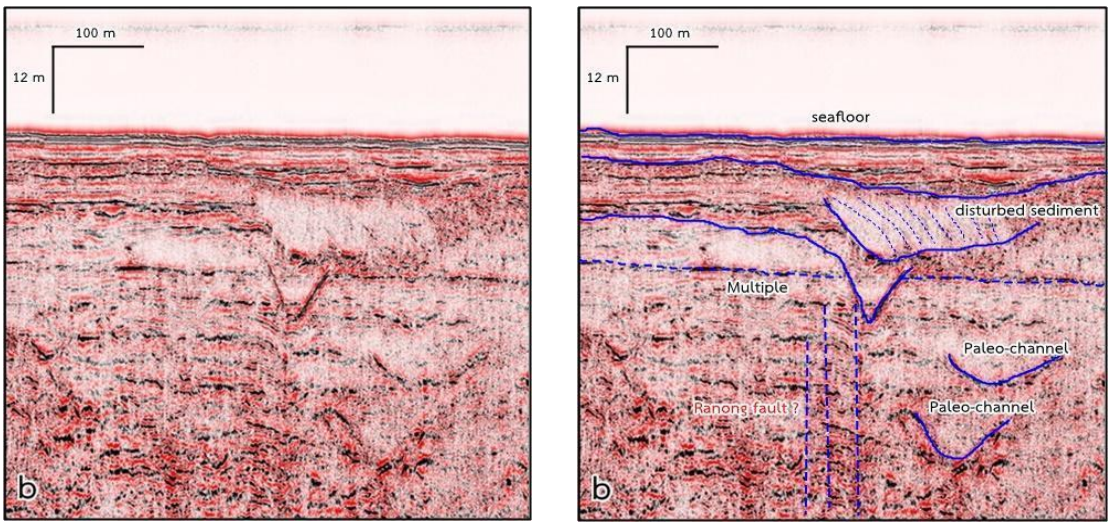


Figure 28 Examples the data before and after interpretation.

(Pananont, 2013)

Seismic data processing was performed using the Geo-Suite. All works software package had run following mathematical operators: spherical divergence correction, de-ghosting, migration, band-pass (250–2000 Hz) swell filter, trace mixing, time vari-ant gain and mute of water column. Signal penetration was found to exceed 500 ms two-way time. The vertical resolution is ~1 m near the seafloor (Barreca et al., 2014). Seismic characteristics such as amplitude, reflection continuity, external shape, and frequency allow us to device depositional processes in the study area (Damuth, 1980). Seismic survey would mention in next chepter (chapter 3).

2.4.4. Definition of seismic units and chronostratigraphy

Based on the internal configuration and seismic-stratigraphy's character of reflectors amplitude, reflection continuity, external shape, and frequency (Damuth, 1980). After improving the data quality, Lamination of the data shows the different data in each place **(Fig.29).** The different data in any places is such as Unit A, translation the data to be mud settling and Unit B that is sediment in the last Quaternary quite to be the sand (Cassinisl et al., 2005).

This seismic facies can be correlated with a sandy and marly succession common in the Pleistocene of the Mediterranean area (Pepe et al., 2003). **The figure 29** non-continuous of the data in Unit B has shown the characters of sand by seismic wave data. Innovative Precast Shear Wall (IPWs) is generally formed seaward of the lower edge of abrasion platforms. They are turn flat areas formed and/or just above the intertidal zone. Above this zone of frequent wet or dry cycling, rock is weakened by subaerial weathering resulting in the formation of silty sands and sometimes coarse sand or gravel sediments (Retallack and Roering, 2012). During storms, sediments are shed downslope to below the storm-wave base. The latter controls the accommodation space and, therefore, the depositional equilibrium profile and depositional shoreline break (Hernández-Molina et al., 2000). The data maybe translate the result to be sand with the characters in turn overlain with Pliocene fine-grained deposits (mudstones and claystones) and Pleistocene coarser deposits (sandstones and siltstones) (Pepe et al., 2014).

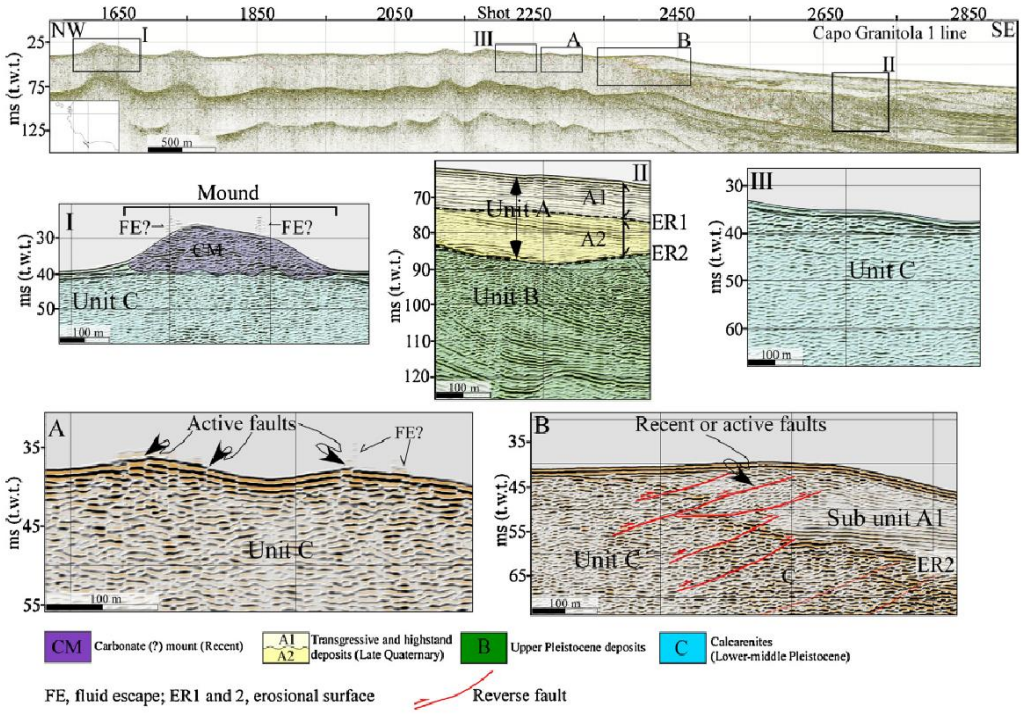


Figure 29 Seismic classification

(Barreca et al., 2014)

2.4.5 The assessment of resources potential area outside the offshore

The assessment to sand at potential area means places which have no founded some sand resources, however it has a tendency that has evidence indicates by geophysics and geology. This cannot surely inform deposit scope of sand, so the quantity of sand resources was estimated. An inferred assessment has been by general outline method that is a too popular and not complicated method (David, 1977).

For the right of data, it is necessary to pierce survey. There is the study area as 4 pits for assembled size and quality of sand resources rightly. This is because the pits of study area can assure the sea bed resources greatly.

CHAPTER 3

Seismic survey

3.1 Plans to survey on fieldwork

3.1.1 Equipment

This is equipment for survey with Shallow seismic reflection profile in the sea. An equipment survey, Shallow seismic reflection profile, has to be high resolution, and there is checking of efficient equipment for Shallow marine seismic reflection from Geo Marine Survey Systems B.V.company. They combined with

1) Solid State Pulsed Power Supplies

Solid State Pulsed Power Supplies **(Fig.30)** is equipment for making and controlling Marine Multi-Tip Sparker System. It is used for setting power and wave frequency. Electromotor Geo Spark 1000 plus model of Geo Marine Survey Systems B.V.company was used in this survey. It has been set to release the power of about 1,000 Joule.

Figure 30 Power Supplies in Geo-spark 1000 Plus

(Geo Marine Survey Systems, 2015)

2) Marine Multi-Tip Sparker system

Marine Multi-Tip Sparker system **(Fig.31)** makes a multi-tip sparker, and high voltage of electric current sparks each other. The water depth, which can observe is from 2 to 500 meters. This survey passed through the deep sea from 200 to 300 micro second, and there is a data resolution at 20 to 30 centimeters. The survey used Sparker Geo-Source 200 Light Weight model of Geo Marine Survey Systems B.V. that gave energy about 1,000 Joule.

Figure 31 Marine Multi-Tip Sparker, Geo-Source 200 Light Weight

(Geo Marine Survey Systems, 2015)

3) Multi-channel Streamers

Multi-channel Streamers got a signal multi-tip from many sequences in the sea. It combined with hydrophone 24, 24 channels. There is hydrophone group spacing 3.12 meters. There is frequent space of multi-channel streamers 10 -10,000 Hz; moreover the streamer line is long about 100 meters. **(Fig.36)**

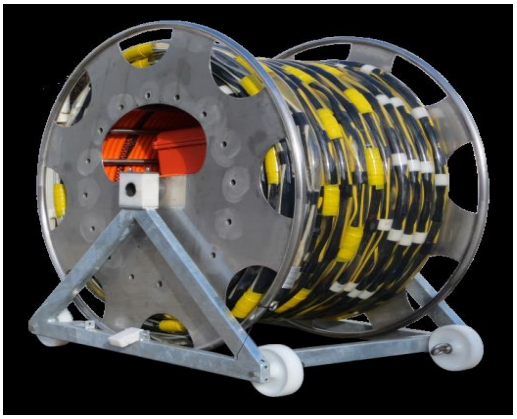


Figure 32 Multi-channel Streamers; 24 channels

(Geo Marine Survey Systems, 2015)

4) Data logger

In the study, seismograph 24 channel of multi trace; Geo Marine Survey systems B.V. Company **(Fig.33)** can save the survey data and geographical coordinate data while a survey with GPS.

Figure 33 Data logger 24 channels

(Geo Marine Survey Systems, 2015)

3.1.2 How to select the survey area

Due to the fact that the coastal area and in Jomtien beach offshore area of changwat, Chonburi continue to survey with shallow marine seismic reflection which cannot survey all. There is a necessary to specify places with many factors **(Fig.34)**. As per below

- Requirement to get more sand for beach nourishment in the places.
- The factors in the area as “Isn't it a conservation place” or “Aren't there a coral reef and artificial reef”
- Rules and laws involved with the survey places.
- Characteristic and distance of the sand area.

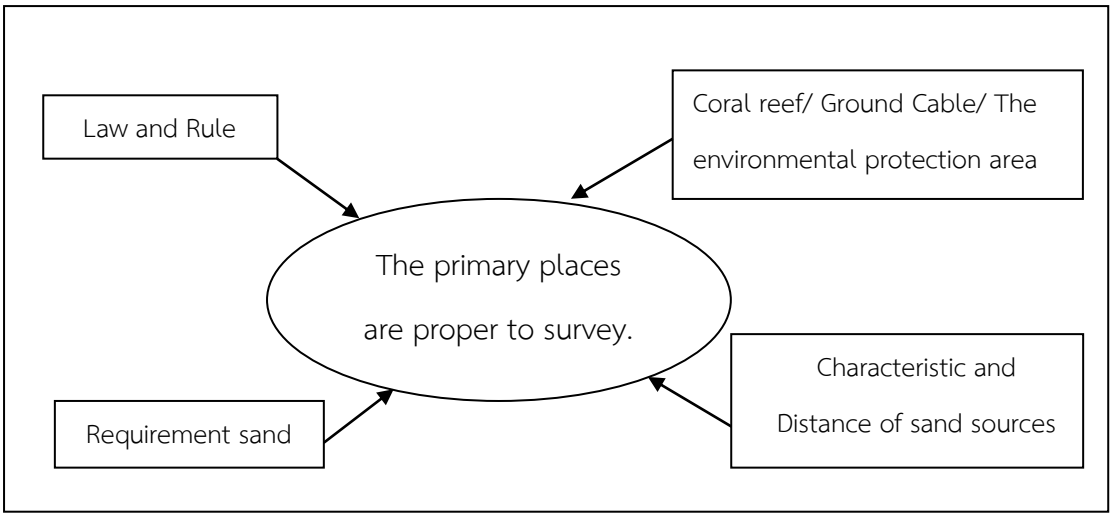


Figure 34 Diagram showing the factors of specify places as primary survey.

(Aquatic Resources Research, 2011a)

3.1.3 Route survey

How to select a survey route has to use Shallow marine seismic reflection survey for an amount of wanted data to do the survey routes. There are two forms of the specific routes that they are a parallel to the coast survey and a perpendicular to the coast survey.

Controlling sea route of geophysics survey uses Global Positioning System: GPS to be in a position. In this survey, it was noted the position per minute with controlling fast levels of the ship for survey to be about 5 - 7 km. / hour.

The survey route is around 80 km. **(Fig.35)**. Total survey area is about 72 km^3. Parallel to the coast survey of the routes was found geography information which is special information of the sand in lower sequence. It was found the information that is perpendicular to the coast on the sea nowadays in ancient channel since during the Pleistocene. Conclusion, the survey used parallel to the coast route survey, it would have seen clearly in the present. It was found the information, specific sand levels data on upper sequence, about perpendicular to the coast geography greatly. The data of sand ridge in the Holocene would behave parallel with the sea coast nowadays, but nowadays perpendicular to the coast has been seen clearer.

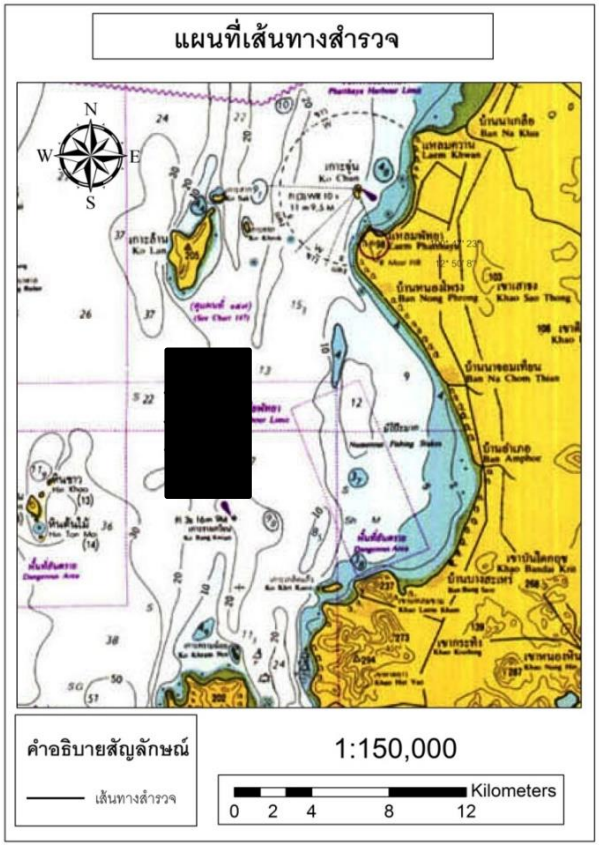


Figure 35 Study area in offshore Jomtien beach

Gathering some data which is useful in assessment to evaluate places takes an opportunity to survey the sand source. For example, sizes of the sediment on the seabed map or the paleo channel map from Department of Mineral Resources etc.

1) The paleo channel map **(Fig.13)** that generally sand sources would be on river ledge or estuary follows the way of channel waved as curves. They come after the topography.

2) Sizes of the sediment on the seabed map or ocean sediment (Shi et al., 2014). This is from the advisers who present the project after a survey cooperation and arrangement of seabed samples by the research team from China around the gulf of Thailand. The data of the sediment size would see the sediment under off Jomtien beach. There is the particle size in order to sand and fine sand which aspect to be sandbar in the Holocene.

3.2 Fieldwork procedures

The acoustic source used to acquire the high-resolution seismic data was a 1 kJ sparker power supply **(Fig.36c)** with a multi-tips Sparker array, which lacks ringing and has a base frequency around 800 Hz, fired at 250 ms time interval **(Fig.36a).** Data were recorded with a multi-channel streamer having an active section of 3.15 m mand containing high-resolution hydrophones **(Fig.36b)**, for 350 ms two-way time at 10,000 Hz (0.1 ms) sampling rate. Vertical resolution reached up to 0.5 m near the seafloor. Then, it was transferred to data logger to analyze Analog to digital **(Fig.36d)**. Navigation was controlled by a DGPS system **(Fig.37b)** and Hypac Survey programs **(Fig.37a).**

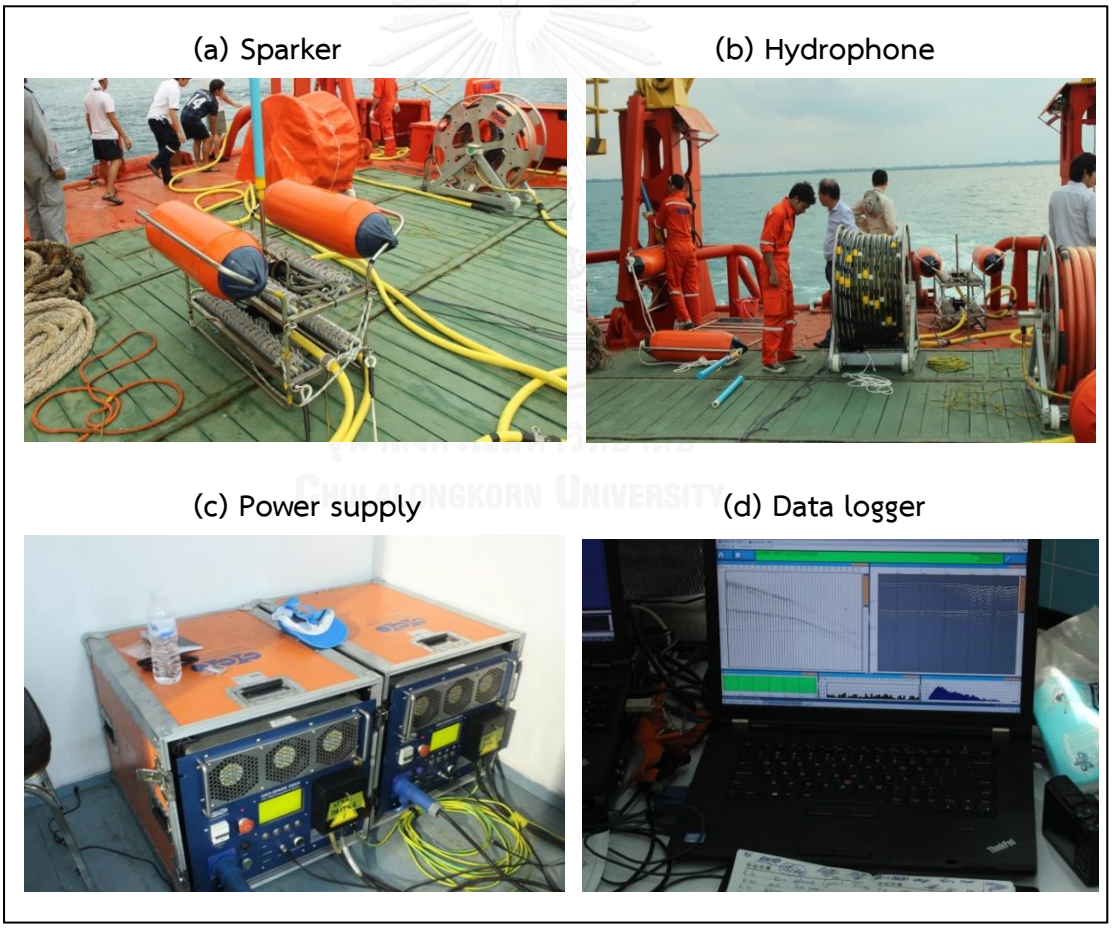
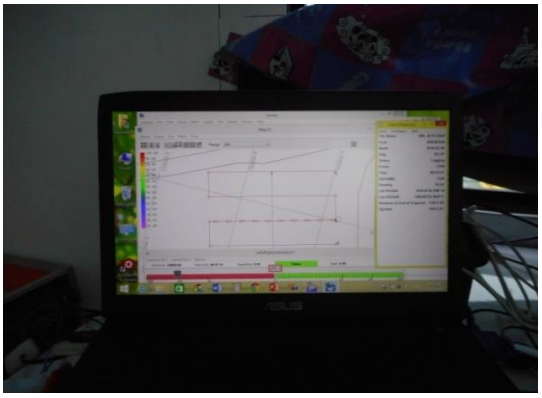


Figure 36 Equipments for seismic surevey

(a) Hypac surver program



(b) Antenna of DGPS

Figure 37 DGPS system and Hypac survey program

3.3 Data processing and enhancement

Processing

Data processing was performed running a series of mathematical operations including: (a) true amplitude recovery using a T^2 spherical divergence correction; (b) band-pass (300–2000 Hz)“finite impulse response” filter using a filter length of 256 samples;(c) de-ghosting, (d) swell-filter; (e) time migration; (f) trace mixing of three traces for enhancing horizontal signal; (g) time variantga in to boost amplitudes of deeper arrivals; (h) mutes to eliminate the signal noise on the water column (Catuneanu, 2006). Signal penetration of the obtained seismic line was found to exceed 350 ms two-way time. Vertical resolution was up to 0.5 m in the near sub-seafloor (Ferranti et al., 2014).

This survey is from multichannel seismic data processing. It was evaluated operators: amplitude recovery, stabilization by signal, muting, deconvolution, velocity analysis, normal move out and stack of the Common Depth Point (CDP), time variant filters, and trace equalization. For our research work, we have converted the images of seismic profiles in Society of Exploration Geophysics "Y" format (SGY) seismic data format. Using the Geo Suite All Works software, which is a comprehensive Geographical Information System (GIS) environment processes and interprets of geological/geophysical data (Sacchi et al., 2014).

Time to depth converses following the seismic facies analysis, route survey seismic line was depth-converted. An average value of 1540 m/s for the sound velocity in the water column between the sea level and -30 m was derived by the sound velocity profiles. This was recorded during multi-beam acquisition. Since no direct information is available on sound velocity of seismic units, we adopted the average velocities of 1700, 2000 and 3300 m/s for the Quaternary, Pliocene deposits and upper Miocene sedimentary rocks, respectively (Loreto et al., 2015). These values were derived from lithological description and sonic logging data available for coeval deposits in 6 wells drilled offshore in Jomtien beach (Pepe et al., 2010). Besides, processing of seismic data included conversion from time to depth of the vertical scale of seismic sections. Correlation between stratigraphic units and seismic velocities was based on analysis of seismic facies and lithostratigraphic data (Di Vito et al., 1999).

3.4 To survey sand resources by shallow seismic reflection profiling

3.4.1 Principal of a basic survey

Main purpose of shallow seismic reflection survey is to be better the underground geological features as in the stratigraphic image which shows as a wave and interprets. The benefits are used as per below.

(1) Economic mineral data resources, petroleum and natural gas resources

(2) The data was used in engineering structure,

(3) The data is for hydro geology and environmental geology so on.

Most of seismic survey methods are the popular early way to work in feasibility study which is a primary data to specify other survey routes. Positioning of equipment in the survey which shows 3 types of equipment and tools **(Fig.38)**. (Fraccascia et al., 2013)

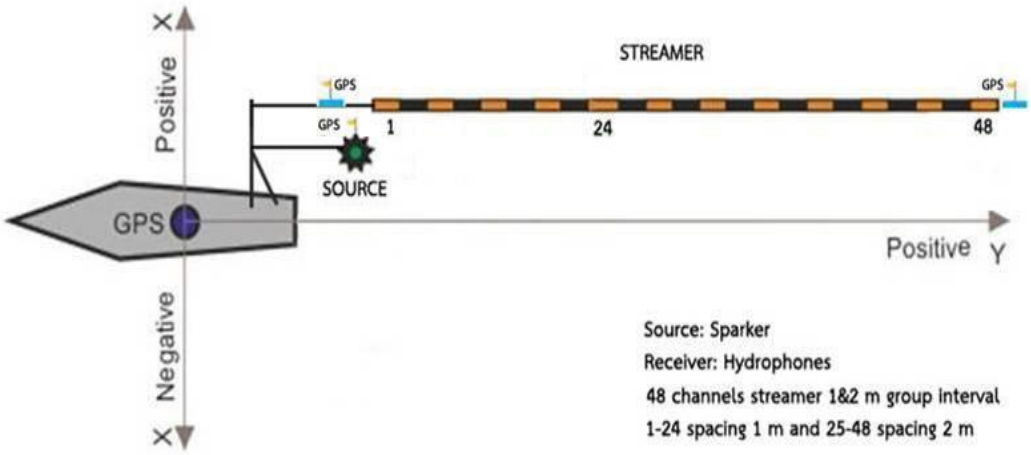


Figure 38 Position of the equipment in a primary survey

(Geo Marine Survey Systems, 2015)

1) Wave sources

Many types of wave sources are used following the wanted signal and energy. For marine survey, there are air gun, water gun, boomer and sparker. In this survey, sparker was used to be the origin of wave.

Sparker consists of two electrodes which are sunk while the sparker was working. It was connected with capacitors, power supply and switch which were electrical control from power supply to capacitors. The capacitors make voltage between capacitors highly to make dielectric breakdown. While the process of breakdown waters split, it becomes quickly ion and electricity passed through two capacitors. It is noticed from short spark like the **figure 39**. Whereas electricity is passing through 2 capacitors, it suddenly releases some heat. Some liquid becomes high-pressure steam speedily, and then it becomes shock wave (bombing by plasma bubble). The characteristic of shock wave spread by Sparker, so it makes the characteristic to be audio signals. In general, Sparker would make signal to have frequency sound wave about 100 - 3,000 Hz or much more. Furthermore it was installed GPS for identify the position to origin of wave.

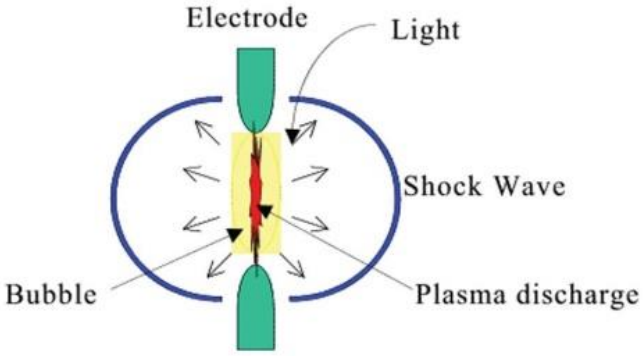


Figure 39 Origin of shock wave by Sparker

(Geo Marine Survey Systems, 2015)

2) Wave Receiver

Receiver of marine survey is hydrophone with 48 channels which is equipment to convert sound energy to electricity. Electric field is from changing of magnitude because of some pressure, so this phenomenon piezoelectric effect.

The receiver for survey under water consists of piezoelectric crystals which is compression and prolongation that they are proportion with velocity to return up waves through water. Returning of waves by hydrophone structure would consist of

1) Piezoelectric which converts sound energy to electricity,

2) Bounded chloroprene rubber which is the water protection,

3) Preamplifier which operates amplifiers to be hydrophone 1 channels.

In the design, receiver would bring a lot of hydrophones connected to be a line into plastic containers. Some solution was contained in a streamer. Normally, the distance of each hydrophone is about 3.12 m. far. For this survey, the design of hydrophone is the special 1^{st}- 24^{th}. The hydrophone designs the distance about 1 m. far, moreover the 25^{th}- 48^{th} were designed the distance around 2 meters far. The design is for a cross section profile of marine geology on the upper level deep to the seafloor about 50 m. finely. Because of the study about sand resources, they mainly are shallow from sea floor. The streamer of stern is around 100 meters. The streamer line would install GPS at the prow and stern to position. GPS was installed along with buoys attached at the first and the end of a streamer **(Fig.40)**.

Figure 40 Hydrophone of 1 channel in the Streamer

3) Amplitude and recorder

Signal from hydrophone would be transfer as analog signal (time, amplitude), when the receiver spreads the signal up to cut-off frequency overload for reading data and dividing trace by multiplexer. After the analog has converted to digital by the converter, it would have recorded to process later.

3.4.2 The principle of seismic wave

Seismic survey is up to the reflection of the wave factors. It was called movement of wave through intermediary, and in the past, it was named reflected wave. Wave that it passes outside intermediaries before reflection called incident wave. Wave reflection happens follow the rules of reflection which called wave front that reflects with reflector at the interface of two intermediaries as angle at reflection wave with reflector. In a short name, it is the angle of incidence as a reflection angle. There is a condition that the surveyed sediment-rock layer in each layer would be different acoustic impedance. Acoustic impedance is a multiple of speed wave and density (V_1P_1). Reflected wave was saved in a form of time and amplitude (Pepe et al., 2003).

1) Feature of seismic survey

Applying the rules of the reflection is to survey sedimentary layers under the sea. Wave source sends incident wave to impact the reflector which makes reflected wave to return to the receiver. A reflection point is in the mid-point between sources and receiver **(Fig.41)**.

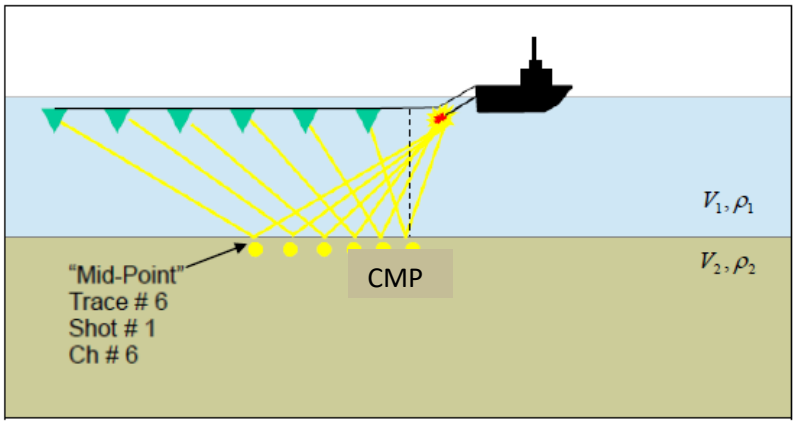


Figure 41 Movement of reflected wave 6 channels

(Geo Marine Survey Systems, 2015)

When the signal spreads out of the receiver to the sea floor, it also impacts with interface of sedimentary layers which have different acoustic impedance. The acoustic impedance reflects to the receiver near the surface of water. Wave signal was recorded in a form of time (T) and amplitude (A). An average of time during the wave signal identifies the distance that wave signal was used on the way to the receiver. Besides, the average of amplitude identifies the different of reflection coefficient (R) at the interface. Reflection coefficient (R) calculates from 1st equation (Ogden et al., 2001).

$$R = \frac{\rho_2 V_2 - \rho_1 V_1}{\rho_2 V_2 + \rho_1 V_1} \quad \text{..... (1)}$$

ρ_1 and ρ_2 are density of the first and second intermediate.

V_1 and V_2 are speed wave of the first and second intermediate.

2) Feature of reflection

Reflected wave has been recorded by the receiver and wave sources at the same position (while reflected wave is at 90°, there is a reflected wave at 90° too). Normal incidence is following the rules of wave (**Fig.42**). Feature of reflection is in study flied **(Fig.43)** that the characteristic geology has the acoustic impedance. Each thickness layer had obviously different, character and thickness. For instance, the **figure 44** present's geology cross section profiles and reflected wave which are recorded at the primary convert time to be the same system.

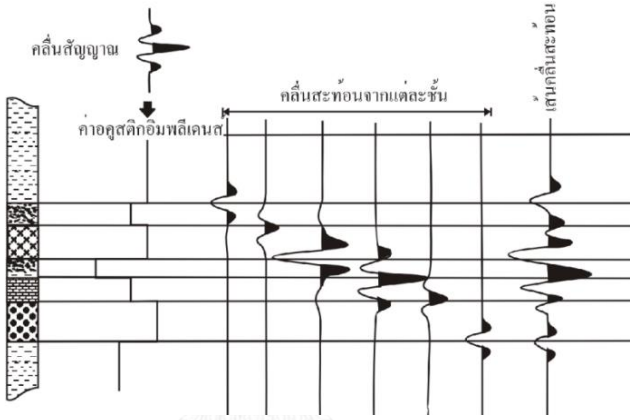


Figure 42 Reflected wave from each recorded layers of various acoustic impedance at the same position along with the depth.

(Sataruşsa, 2007)

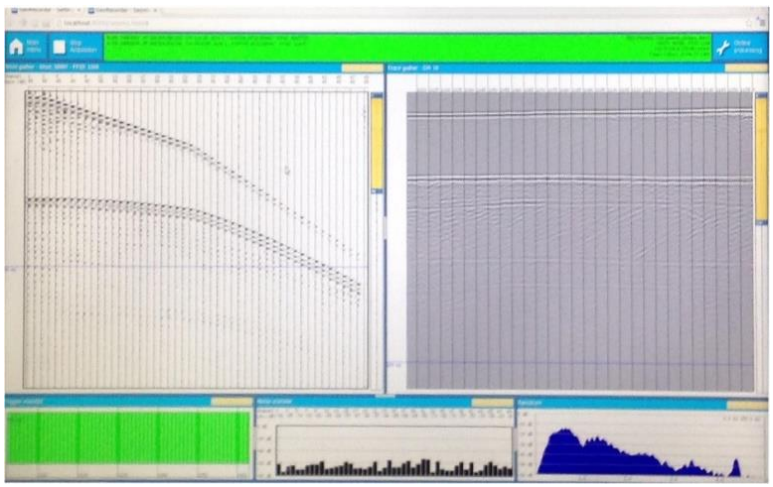


Figure 43 Reflected wave 48 channels (left) and the primary cross section (right)

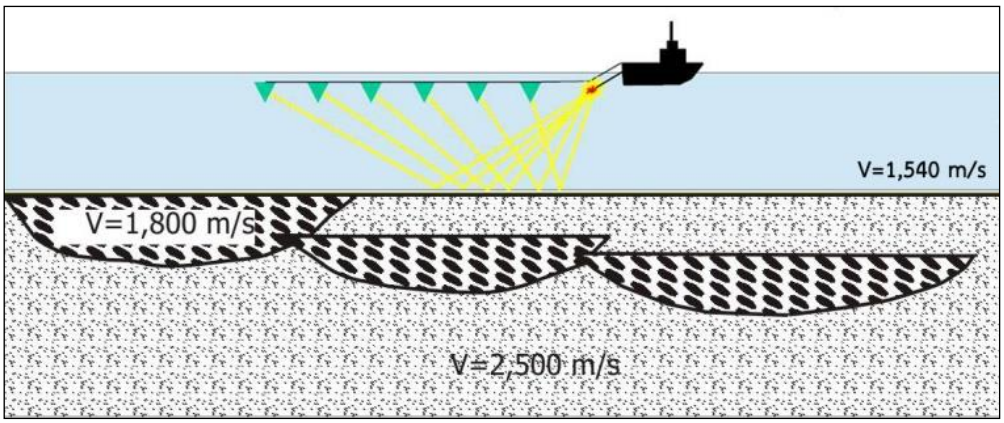


Figure 44 Geology cross section profile of the paleo channel

(Satarugsa, 2007)

3.4.3 Interpretation seismic reflection

Seismic interpretation is up to characteristics information whether is necessary to have a process with any methods and less or more. Normally, there are a few necessary ways to do as per below (Aquatic Resources Research, 2011b).

1. **Primary audit Information**
2. **Pre-process of data preparation before mathematics processing**
   - **DE multiple** is reading the sort data to be series in a tape as trace.
   - **Reformat** is selection of format processing properly.
   - **Edit** is a modification of trace.
   - **Recording geometry** puts field work form of data.
   - **Field static correction** edits elevation of thickness to set Datum levels of seismic section properly.
3. **Band pass filter** tips other frequency signals that they aren't interested.
4. **Common midpoint sort** is how to sort data of ray path which reflects and conclude at the same position together (CMP gather).
5. **Muting** is how to tip signal of the surface wave and refracted wave.
6. **Balancing or Equalization** is how to add more amplitude to the fuzzy signal. This is because of the reflection from the too depth under the sea floor. It concentrates and adds more signal to ray path in the same CMP gather to give balance energy.

7. **Normal move out correction** is to find the differences of time in ray path. In CMP gather, it compares spending time of ray path which reflects right angle (t0), and then it is retrenched time to be a trace as t0.

8**. Velocity analysis** is to do a trial by adding important parameters which specify the speed of the various times into CMP gather. To random speed value tests appropriately to get a trace of reflector clearly.

9. **Stacking** is how to conclude total signal in CMP gather to reflect at the same position with modifying to move out time normally. Specification of the parameter appropriately concludes to be a representative as the value of time of ray path, a perpendicular reflector. 1 CDP gathers to be a signal 1 trace.

10. **Post-processing** is after stacking of every CDP, taking trace sorts CDP station to take Seismic section which maybe processes again with other methods.

After processing has a result to be seismic time section, it is arranged of CMP station compared with datum levels. Each trace is time to pass through vertical formation to incident and reflect. Trend of amplitude orders along the line, however there are a few curves that they can reflect shapes and sizes of the reflector (Catuneanu, 2006; Mitchum Jr et al., 1977). The reflector reflects geology of characteristics' different density. Identity can observe to identify the important structures such as regional fold, unconformity, dome, dike, flow, basement and so on (Carlson and Herrick, 1990).

3.5 Drilling

Tools and equipment

1. Rotary drilling, one of a kind of driller, adheres steel poles to install on tak boat which is a drilling rig that has been water pump, drill stem AW, pipe joints, cutting head, casing (size of φ about 3-4 inch.), equipment for sample test of water pump and an exploration drilling on the raft.

2. Standard penetration test (SPT) as in ASTM D 1586 consists both iron anvil and donut hummer about 63.5 kilograms. Cylinder is 2 inch outside diameter, $1^{3/8}$ inch inside diameter and 18 inch long.

3. Tools which are used in a laboratory are water content, unit weight test, sieve analysis, hydrometer test, unconfined compression, consolidation testing machine, Waterberg limit of oven test and digital scale, etc.

Process of a borehole data

Borehole in the studied area is on the process of Standard penetration test (SPT) as per below. Installation of drilling machine and three-legged frame is at the borehole location. First, drill stem, second, cut head with rubber band, third, do water pump, then start the drilling machine **(Fig.45)**.

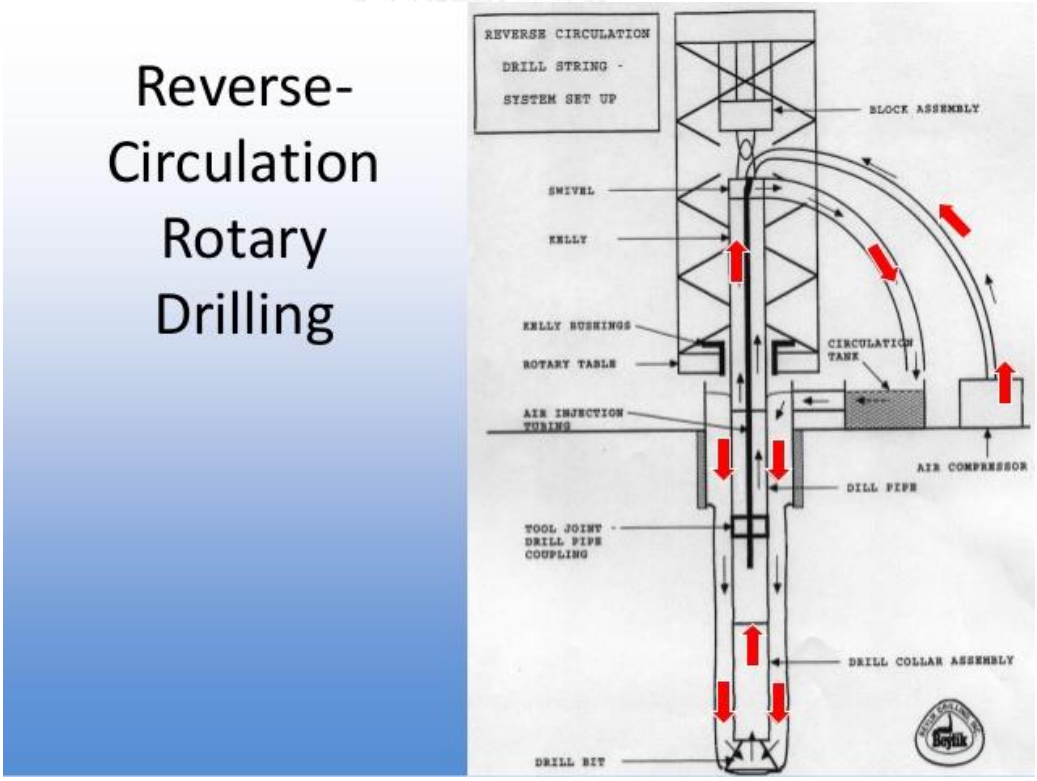


Figure 45 Standard penetration test (SPT) of tools and equipments

(Livingstone, 2007)

Figure 46 Drilling in Jomtien offshore

(ITALIAN-THAI DEVELOPMENT PLC, 2011)

Procedure of drilling (Fig.46)

- To enter casing of below tip down into the ground, then to push down about 1 m. and to fix with the drilling rig.
- To enter a drilling stem and cutting head into the casing, then wash the hole from the earth surface to the casing.
- Using a grille to carry some water, sand sediment or sand following the water from the casing. Then, keeping all samples into plastic bag or any wares to note the soil characteristic as in the deep borehole.
- To press the casing down to the depth 1 m. later and wash borehole samples. After that, drilling to stop the specific late depth.
- Samples of drilled sediment survey were early analyzed and taken to test the qualification of soil size, sticky and moisture sediment on the laboratory.

CHAPTER 4

Survey results

4.1 Interpretation seismic data

Seismic data indicator has changed of characteristics of cross section profile. Preliminary classifications are from principles of 2-D seismic interpretation (Reijenstein et al., 2011) **(Fig.47)**.

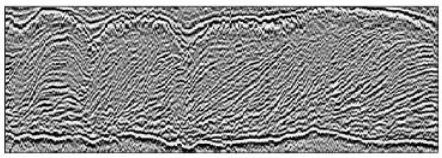
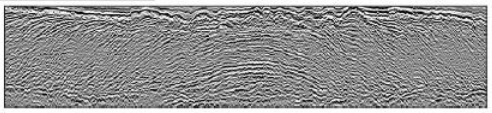
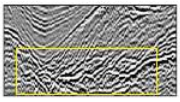
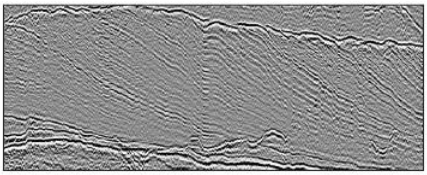
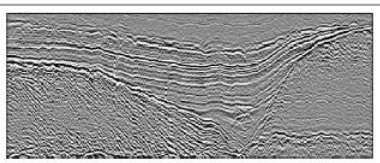
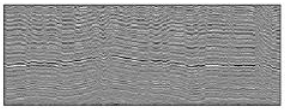
2-D Seismic Facies	Reflection Character / Sedimentologic Interpretation
	**Convex-up lateral accretion surfaces. High-amplitude inclined seismic facies** Point-bar lateral accretion surfaces as seen in a dip-view cross section; Convex-up geometry with downdip increase in slope: 0.49° to 0.62° (point-bar tops) and 0.48° to 3.74° (basal point bar).
	**Convex-up bidirectional downlap; High-amplitude inclined seismic facies** Point-bar lateral accretion surfaces as seen in a strike-view cross section
	**Low-amplitude chaotic seismic facies** Reworked point-bar top deposits
	**High-amplitude channel lag seismic facies** Basal coarse-grained channel lag
	**Concave-up clinoforms; Low-amplitude inclined seismic facies** Clinoform deltaic mouth bar deposits; Concave-up geometry with downdip decrease in slope: 1.76° to 2.04° (clinoform tops) and 0.37° to 0.91° (basal section)
	**High-amplitude, confined, laterally continuous reflections; Seismic terminations onlap against valley walls** Early transgressive estuarine muddy facies
	**Low-amplitude (transparent), laterally continuous seismic facies** Open marine muddy facies

Figure 47 Primary principle interpretation of 2-D seismic data

(Reijenstein et al., 2011)

4.2 Borehole data

Survey drilling positions outside Jomtien beach are 6 boreholes **(table 5)**. Water depth is 10 – 27 m., and drilling depth is 5 – 11.5 m. **(table 6)**. The 6 borehole drilling is in seismic routes survey **(Fig.48)**. Stratigraphy of 6 boreholes show in the **figure 49**. The seismic stratigraphy result of 6 borehole drilling (Carlson and Herrick, 1990).

Borehole	Position		Depth (meters)	Depth of Borehole (meters)
	N	E		
BH-1	142 1269	694 893	26.50	8.45
BH-2	142 1076	694 445	27.00	5.45
BH-3	141 9029	693 451	22.00	11.00
BH-4	141 8992	694 642	21.70	11.00
BH-5	141 7066	693 383	23.00	11.50
BH-6	141 6741	694 886	21.50	11.50

Table 5 The results of borehole data

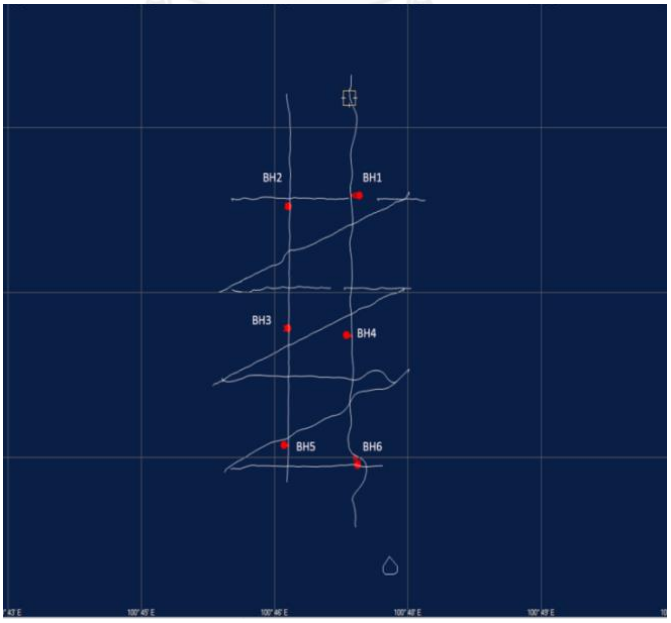


Figure 48 The seismic routes survey and the all position

Position	Depth of borehole	Classification
BH1	0 - 0.18	Clay
	1.9 – 5.6	Medium Sand
	5.7 – 8.0	Fine Sand
	8.1 – 8.45	Sandy Clay
BH2	0 – 2.2	Clay
	2.3 – 4.9	Fine Sand
	5.0 – 5.45	Coarse Sand
BH3	0 – 2.6	Clay
	2.7 – 6.4	Medium Sand
	6.5 – 8.9	Fine Sand
	9.0 – 10.5	Sandy Clay
	10.6 – 11	Clay
BH4	0 – 1.4	Clay
	1.5 – 6.7	Medium Sand
	6.8 – 7.8	Sandy Clay
	7.9 – 9.4	Clay
	9.5 – 11.5	Medium Sand
BH5	0 – 2.1	Clay
	2.2 – 6.7	Medium Sand
	6.8 – 7.9	Coarse Sand
	8.0 – 8.4	Medium Sand
	8.5 – 9.3	Fine Sand
	9.4 – 10.7	Sandy Clay
	10.8 – 11.5	Clay
BH6	0 – 1.6	Clay
	1.7 – 6.5	Medium Sand
	6.6 – 8.8	Fine Sand
	8.9 – 10.4	Sandy Clay
	10.5 – 11.5	Clay

Table 6 The result of sorting from drilling

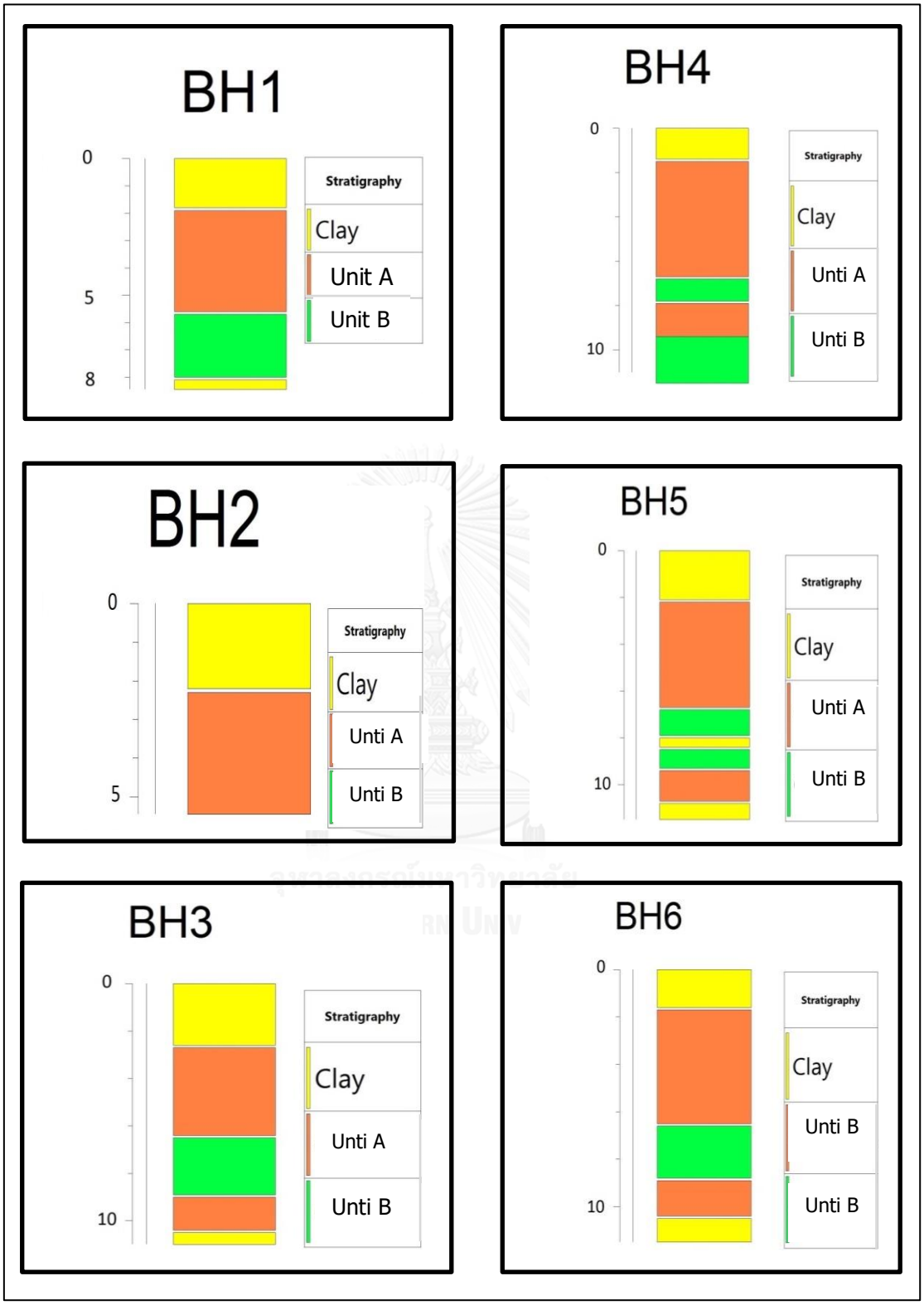


Figure 49 Result of borehole data BH1 – BH6

4.3 The result of seismic data and interpretation

Seismic survey uses high resolution shallow seismic reflection out of Jomtien offshore at Chonburi province, on November 12, 2015. There are 11 survey lines that can include the whole distance about 80 km. or 72 km^3 **(table 7)**.

Route	Route of distance (km)	Seismic data (km)
Line 1	6	0
Line 2	6.5	0
Line 3	6	5.3
Line 4	6.5	6.2
Line 5	6	5.6
Line 6	6.5	6.3
Line 7	6	5.7
Line 8	6.5	6.1
Line 9	6	5.6
Line 10	12	11.2
Line 11	12	11.8
รวม	80	63.6

Table 7 Distance of seismic survey

After finished surveys and processes of data, it shows cross section profile of studied area **(Fig.50 - 52)**. Then, the interpretation of data has observed the changing data, density, color and other environmental elements with interpretation of surveyed seismic.

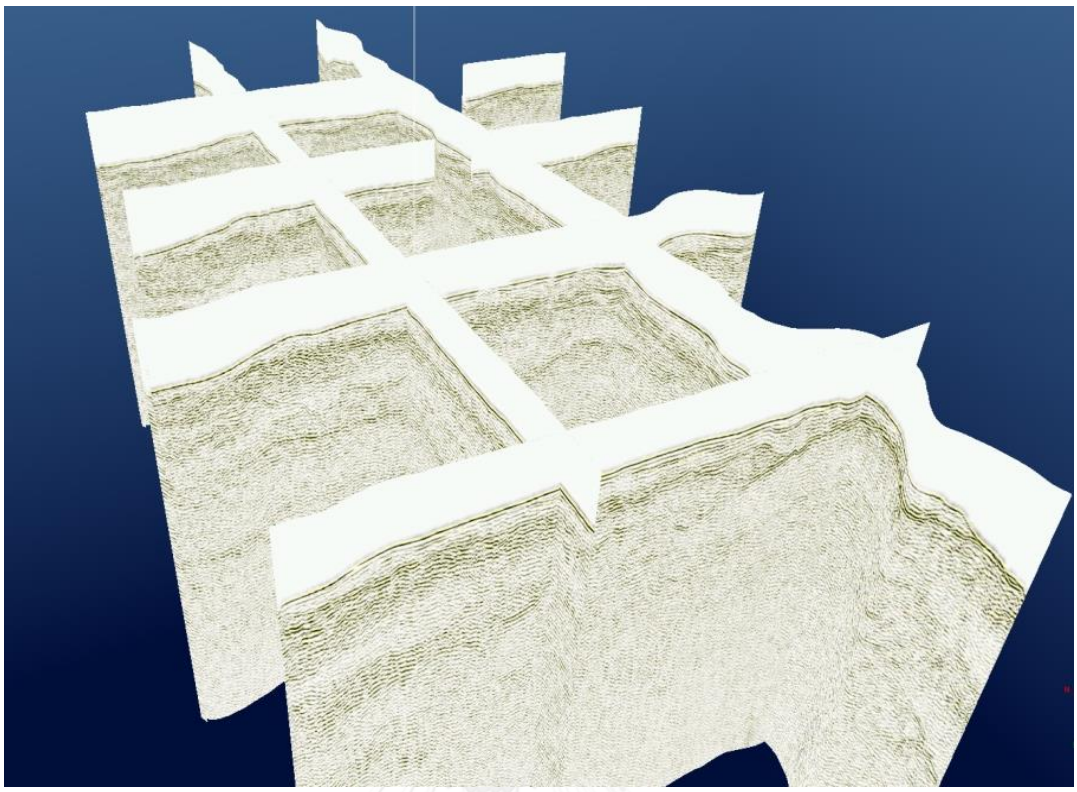


Figure 50 Overview of data from surveyed seismic

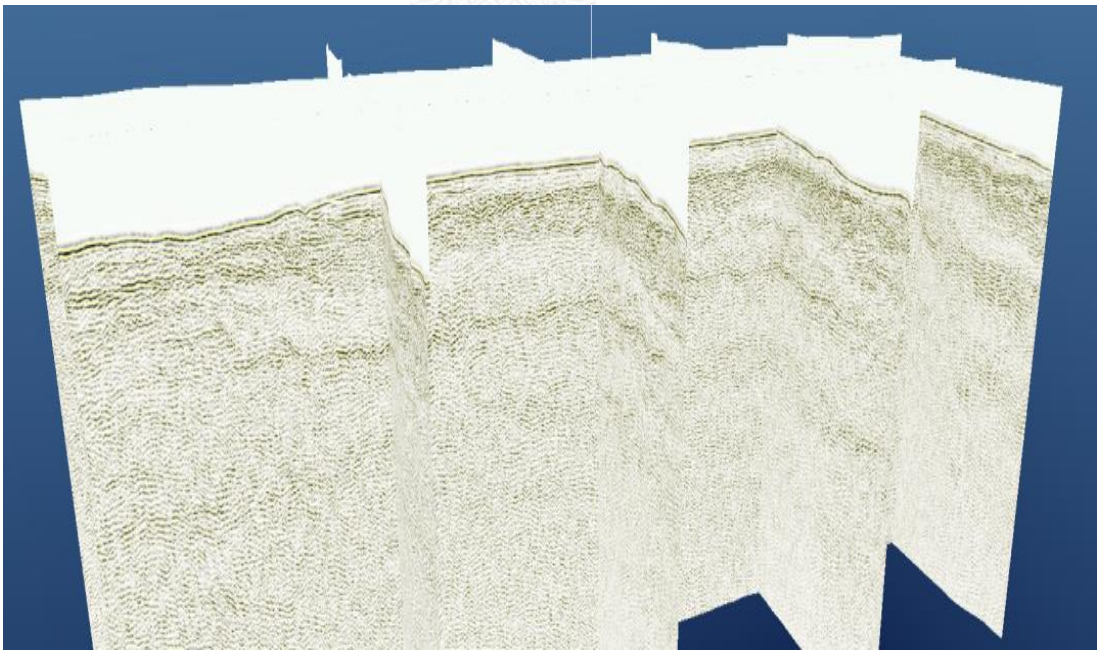


Figure 51 Overview of data is from surveyed seismic; 1st side

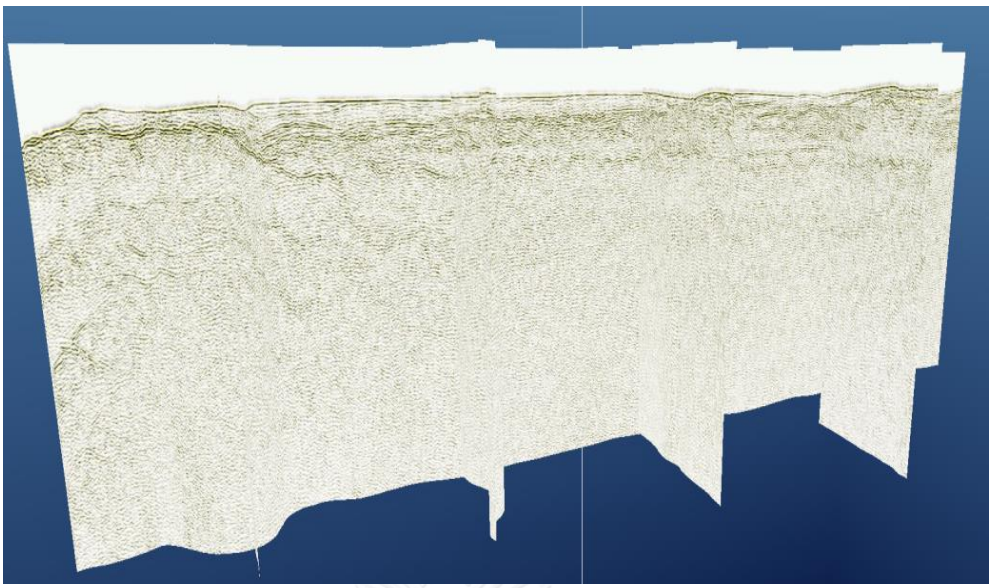


Figure 52 Overview of data is from surveyed seismic; 2nd side

Classification of chronostratigraphy

Chronostratigraphy of the seismic data is separated following the changing data after the processing data. After that, data has been interpreted by changing of data, density, color and other environmental elements. Moreover, it is combined interpretation of surveyed seismic which is not in deep to 50 m. from the seabed. For seismic results **(Fig.55-63)**, this study can sort out the occurring chronostratigraphy 4 units. Following **Unit A, Unit B, Unit C, Unit D**, **uUnit A** as pink is happened the slowest. **Unit B** is orange. Then, **Unit C** as purple has a characteristic like ancient channel. Finally, **Unit D** that happened of green **(Fig.53)**.

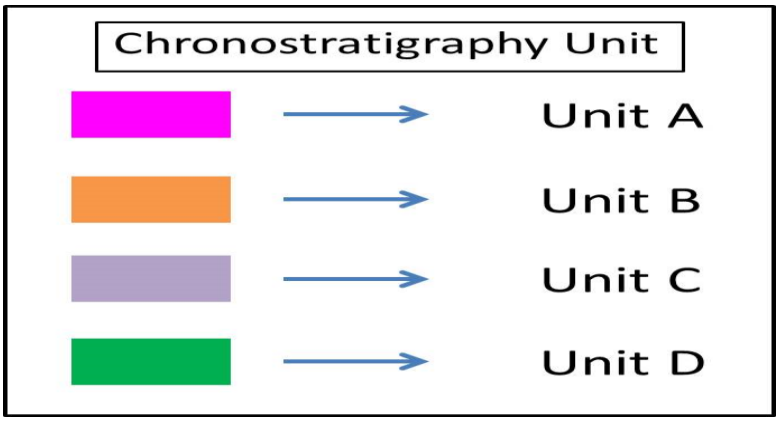


Figure 53 Chronostratigraphy Unit

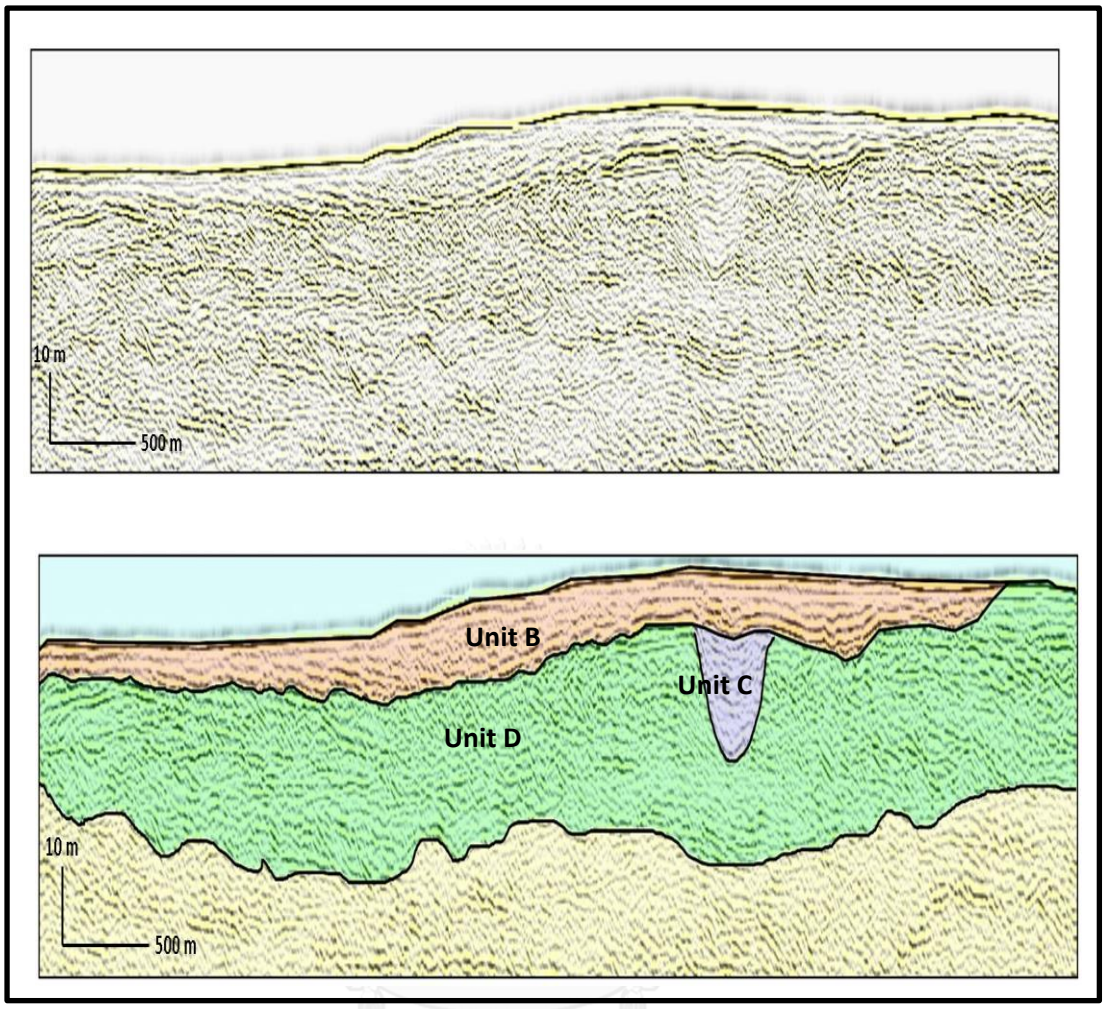


Figure 54 Cross section profile before and after the result of route 3th

Route 3rd **(Fig.54)**, before and after analysis of seismic with data logger, is analyzed with interpreted. This surveyed line is along the east to west around 5.3 kilometers.

Unit B that is thick from the seabed about 3 - 10 meters, and it is on the top. **Unit C** has a characteristic like an ancient channel that connects with 4th, 5th, 6th, 8th and 9th surveyed lines. There are wide 400 meters and deep 12 meters. And the last, **unit D** has a thickness of sediment levels about 12 - 22 meters.

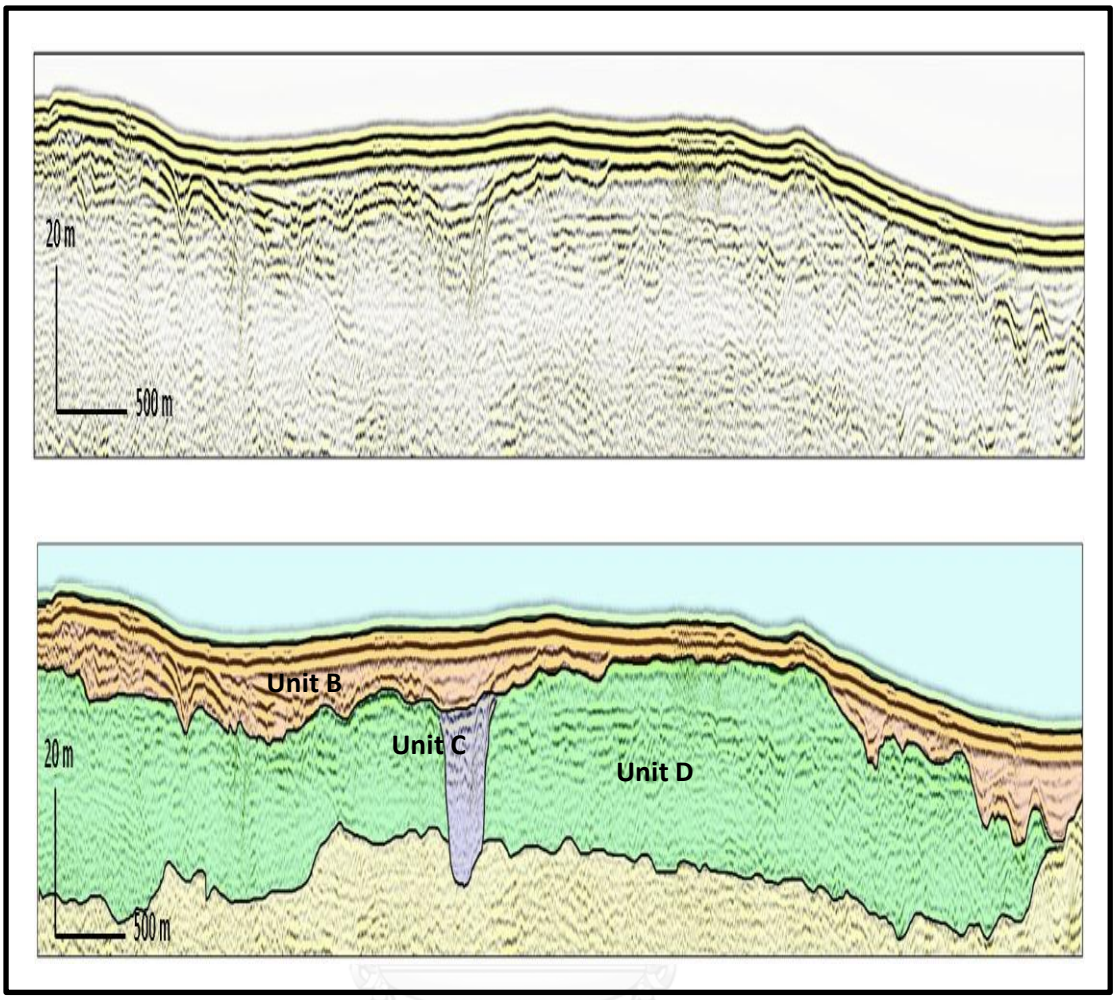


Figure 55 Cross section profile before and after the result of route 4th

Route 4th **(Fig.55)**, before and after analysis of seismic with data logger, is analyzed with interpreted. This surveyed line is along the north east to south west around 6.2 kilometers.

Unit B is thick from the seabed about 5 - 10 meters, and it is on the top. **Unit C** has a characteristic like an ancient channel that connects with 3rd, 6th, 8th and 9th surveyed lines. There are wide 450 meters and deep 5 meters. And the last, **unit D** has a thickness of sediment levels about 13 - 25 meters.

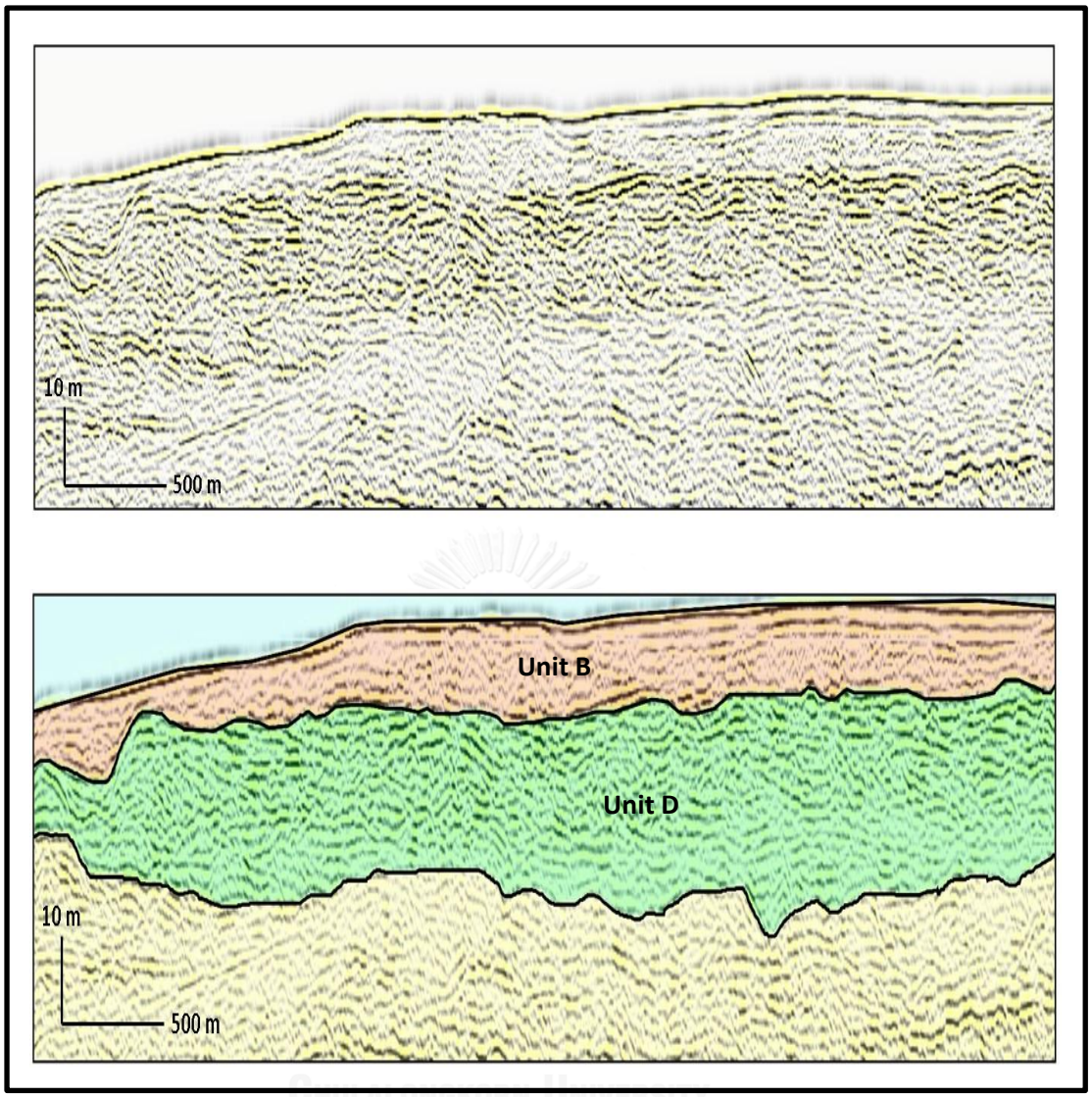


Figure 56 Cross section profile before and after the result of route 5th

Route 5th **(Fig.56)**, before and after analysis of seismic with data logger, is analyzed with interpreted. This surveyed line is along the east to west around 5.6 kilometers.

Unit B that is thick from the seabed about 5 - 12 meters, and it is on the top. Then, **unit D** has a thickness of the sediment layer about 12 - 25 meters.

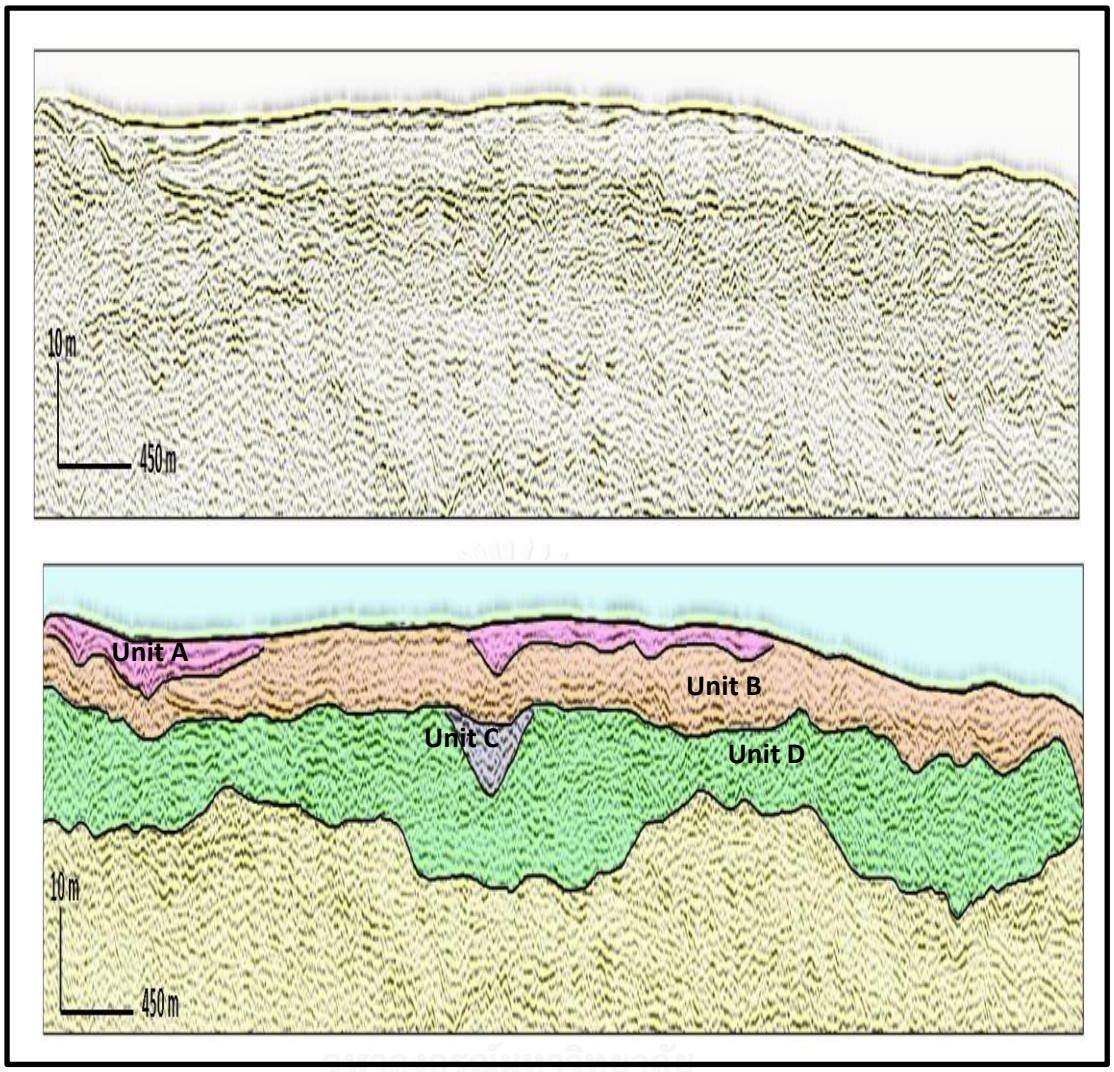


Figure 57 Cross section profile before and after the result of route 6th

Route 6th **(Fig.57)**, before and after analysis of seismic with data logger, is analyzed with interpreted. This surveyed line is along the north east to south west around 6.3 kilometers.

Unit A that is thick from the seabed about 2 - 5 meters, and it is on the top. Then, **unit B** has a thickness of the sediment levels from the seabed about 5 - 10 meters. **Unit C** has a characteristic like an ancient channel that connects with 3rd, 4th, 8th and 9th surveyed lines. There is wide 450 meters and deep 8 meters. And the last, **unit D** has a thickness of sediment levels about 10 - 20 meters.

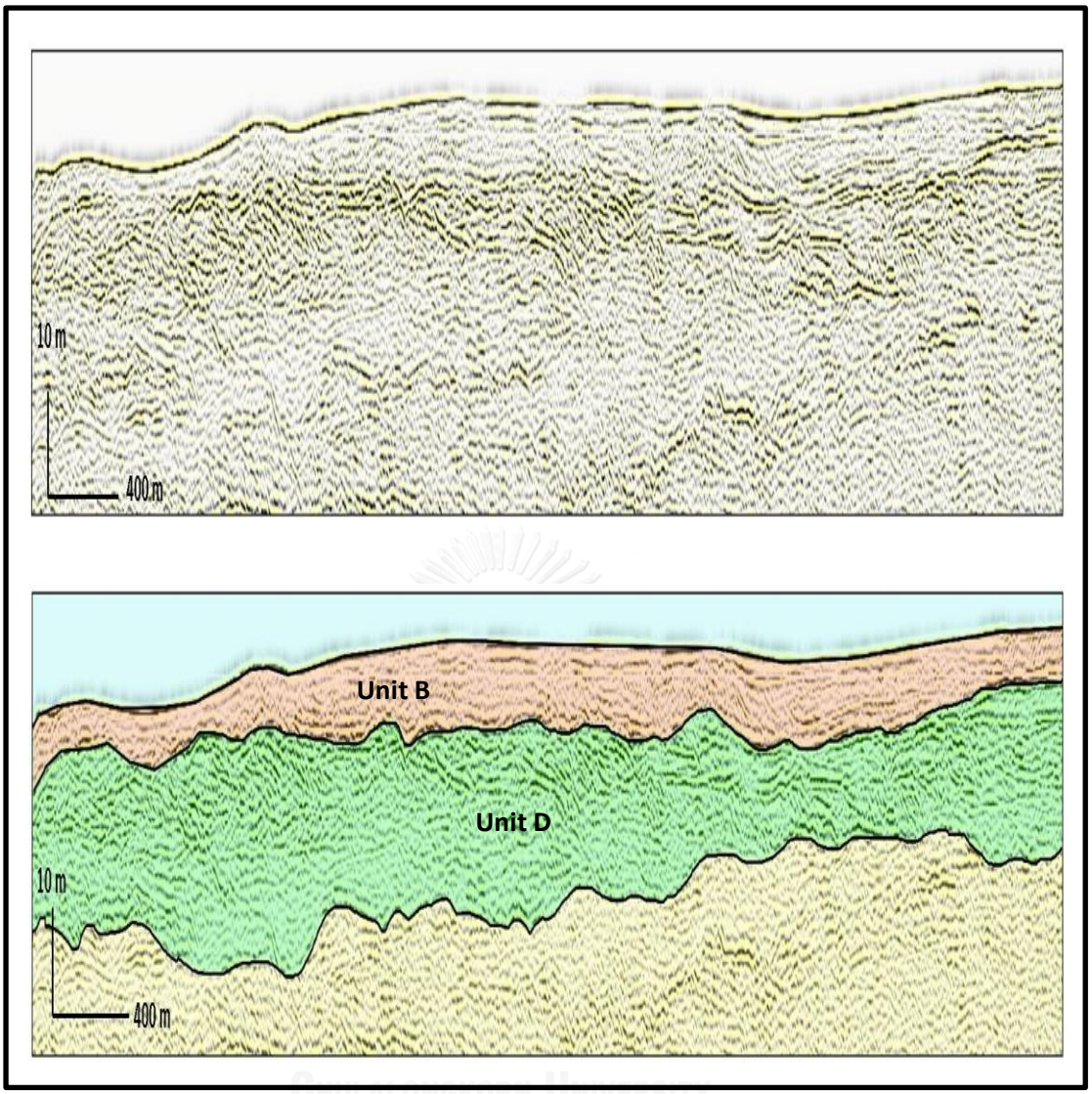


Figure 58 Cross section profile before and after the result of route 7th

Route 7th **(Fig.58)** that is from before and after an analysis of seismic with data logger is analyzed with interpreted. This surveyed line is along the east to west around 5.7 kilometers.

Unit B is thick from the seabed about 4 - 10 meters, and it is on the top. Moreover, **Unit D** has a thickness of the sediment levels about 8 - 20 meters.

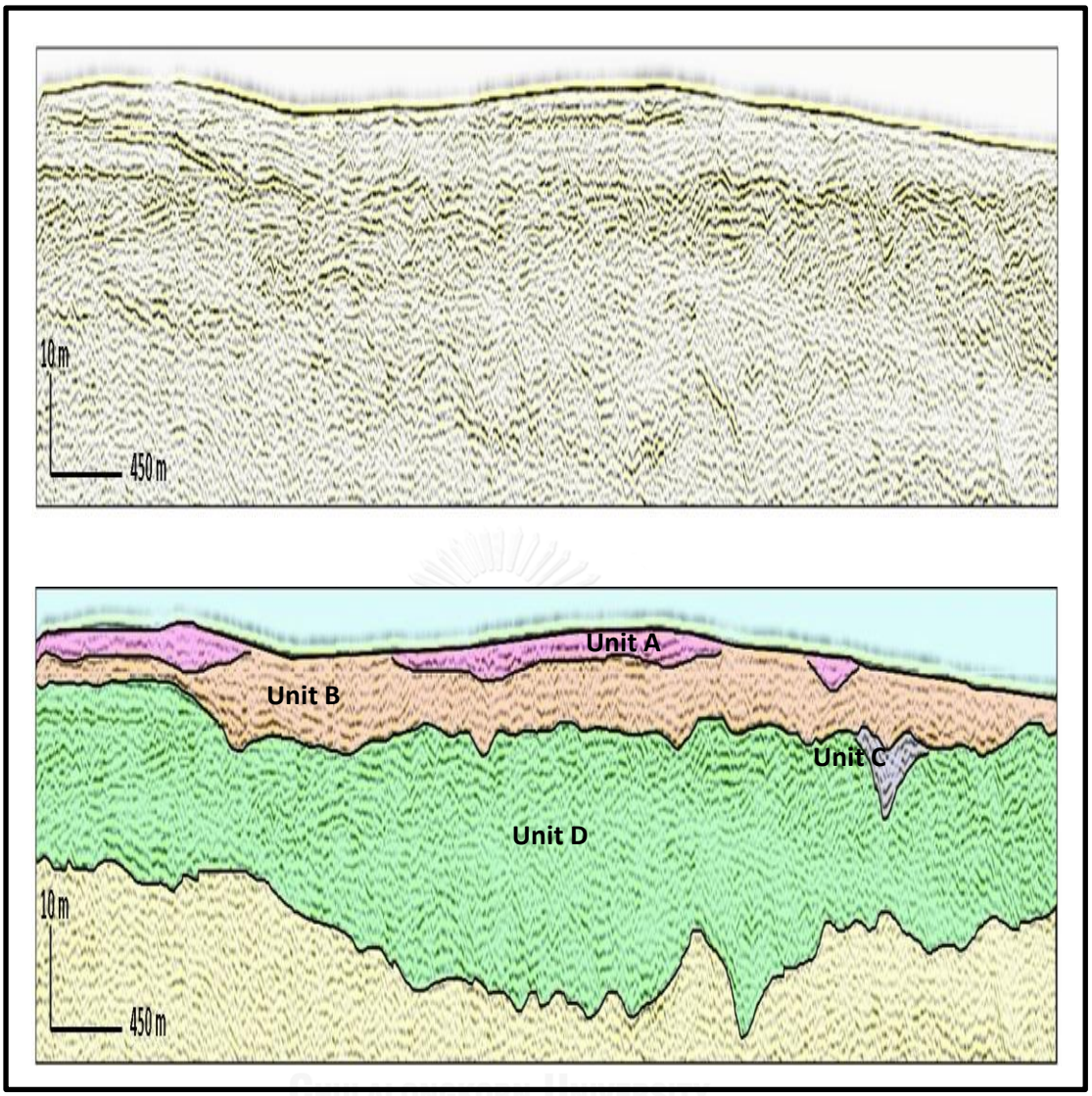


Figure 59 Cross section profile before and after the result of route 8th

Route 8th **(Fig.59)** that is from before and after an analysis of seismic with data logger is analyzed with interpreted. This surveyed line is along the north east to south west around 6.1 kilometers.

Unit A which separates to be many pieces and thick from the seabed 1 - 4 meters is on the top. **Unit B** is too thick for 5 - 10 meters from the south west disappearing to the north east. **Unit C** has a characteristic as connected canal from 3rd, 4th, 6th and 9th surveyed lines. The ancient channel is deep 8 meters, wide 300 meters. **Unit D** has a thickness of sediment levels around 10 - 22 meters.

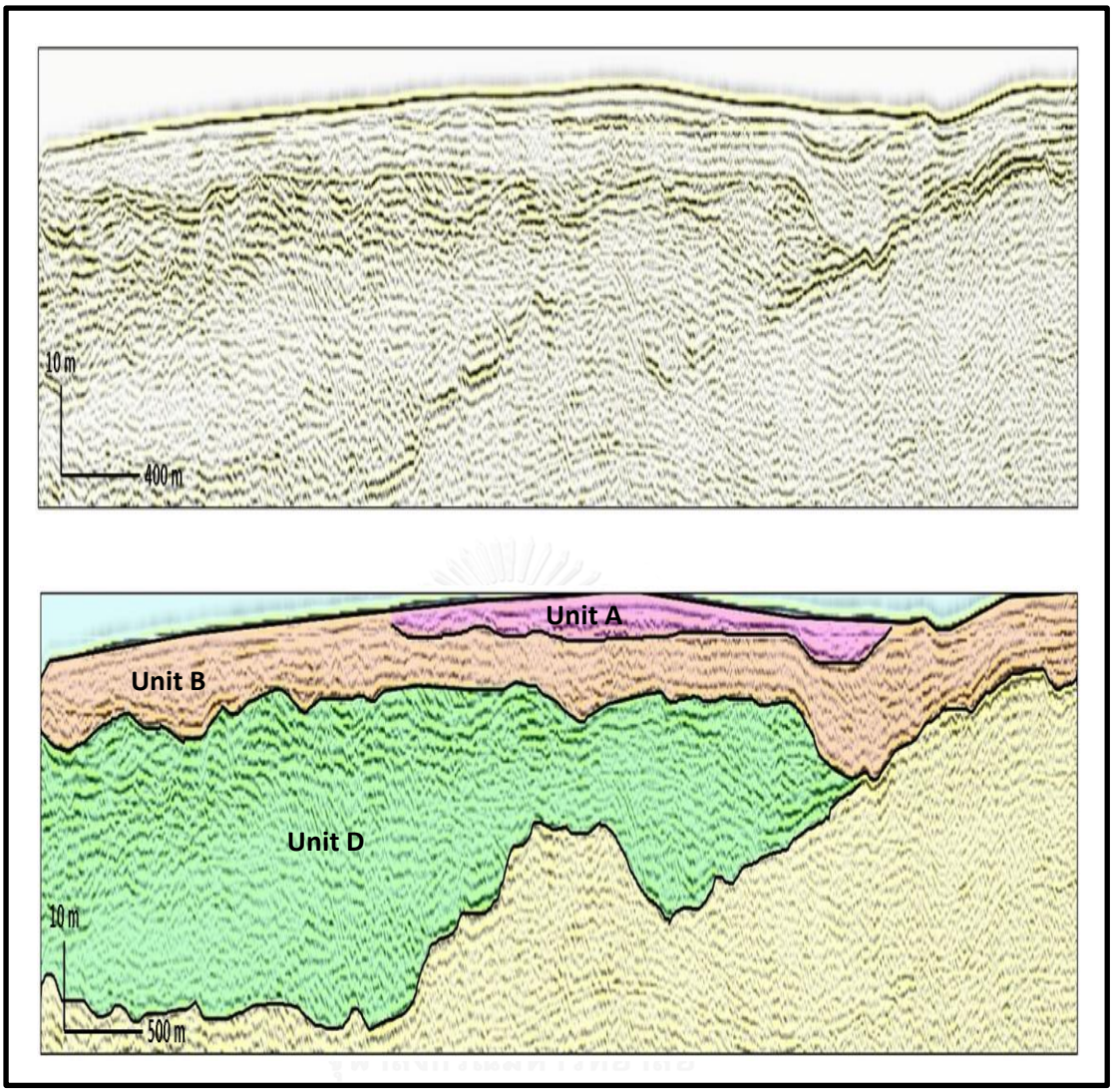


Figure 60 Cross section profile before and after the result of route 9th

Route 9th **(Fig.60)** that is from before and after of analysis of seismic with data logger is analyzed with interpreted. This surveyed line is along the east to west around 5.4 kilometers.

Unit A which separates to be many pieces and thick about 2 - 5 meters is on the top. **Unit B** has thickness of sediment size from the seabed around 8 - 10 meters. And, **unit D** is too thick about 15 - 36 meters in the west, and it disappears in the east.

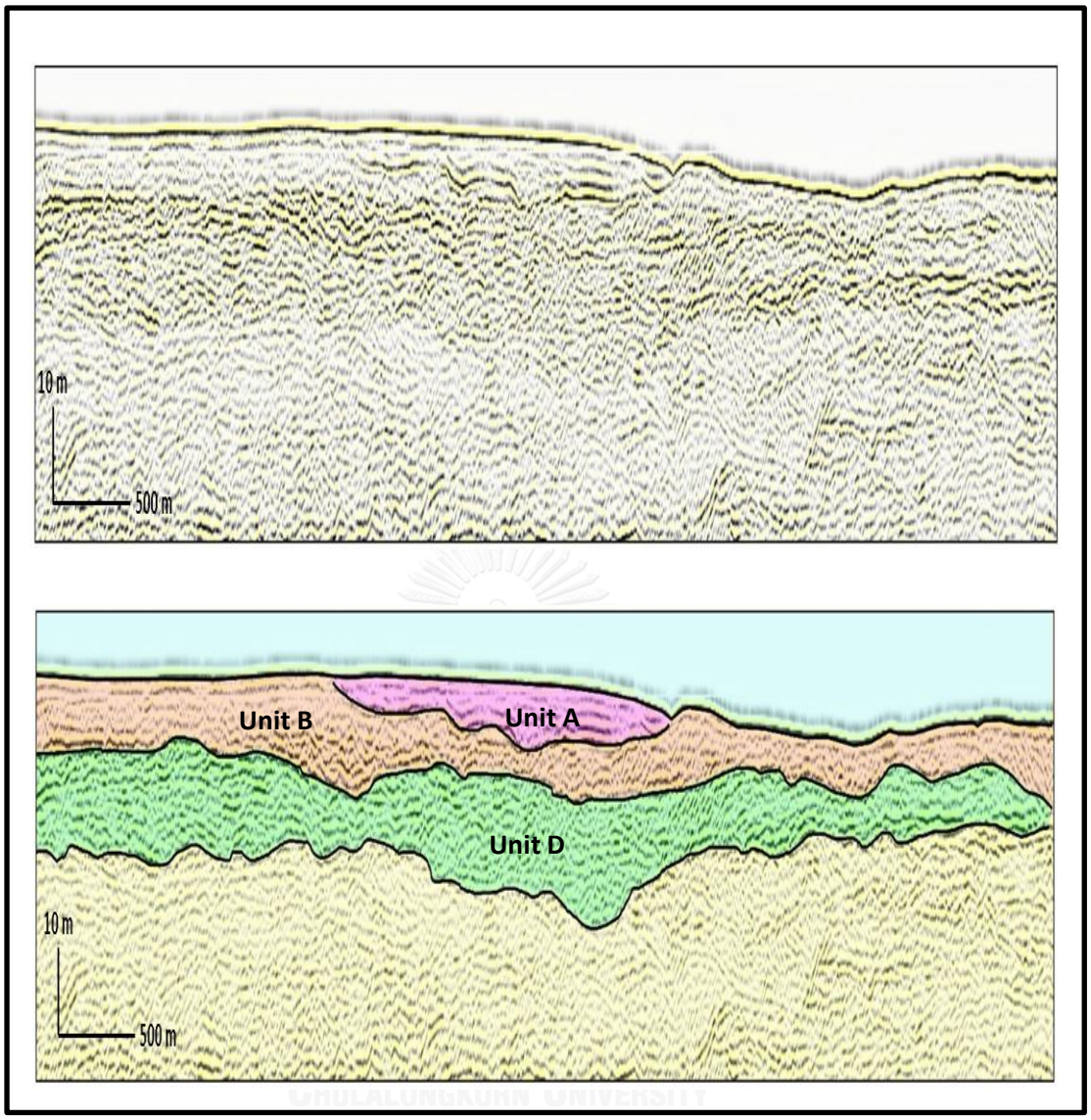


Figure 61 Cross section profile before and after the result of route 10th

Route 10th **(Fig.61-62)** that is from before and after of analysis of seismic with data logger is analyzed with interpreted. This line is long in the north and south way. This way is the longest way that has distant 11.2 kilometers. The data is rather cloud with data logging, so it combines with data logging to interpret precisely.

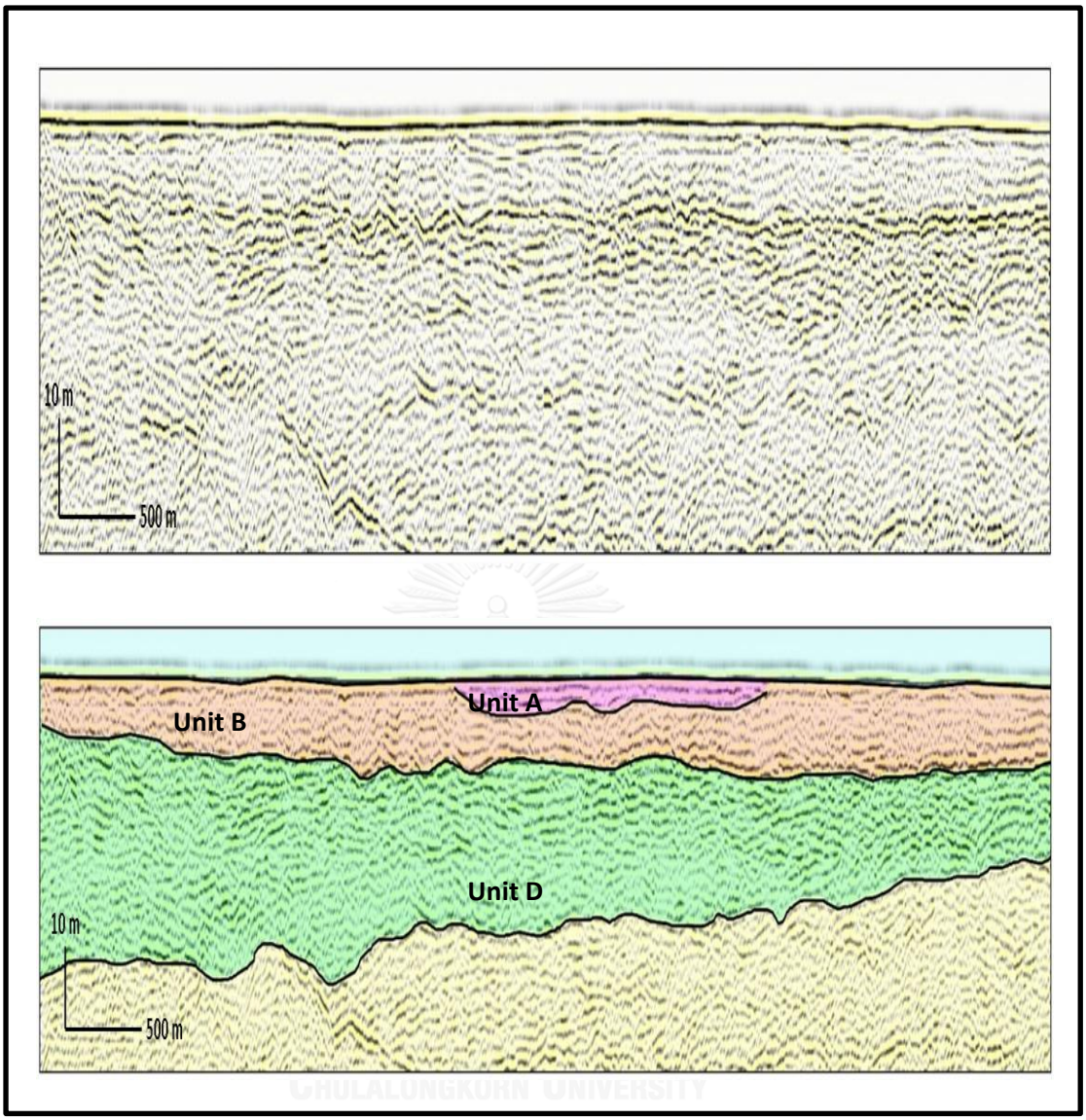


Figure 62 Cross section profile before and after the result of route 10th (continue)

Unit A which separates to be many pieces and thick about 2 - 4 meters is on the top. **Unit B** which is switched part with **unit A** is short area along the way. The thickness of sediment size is from the seabed around 8 - 10 meters. Then, **unit D** is thick 16 - 20 meters in the north and quite slim about 6 - 9 meters. **Unit D** has a characteristic as arranged **unit B** which is thick sediment levels in the north but slim in the south. There is 8 - 30 meters of sediment.

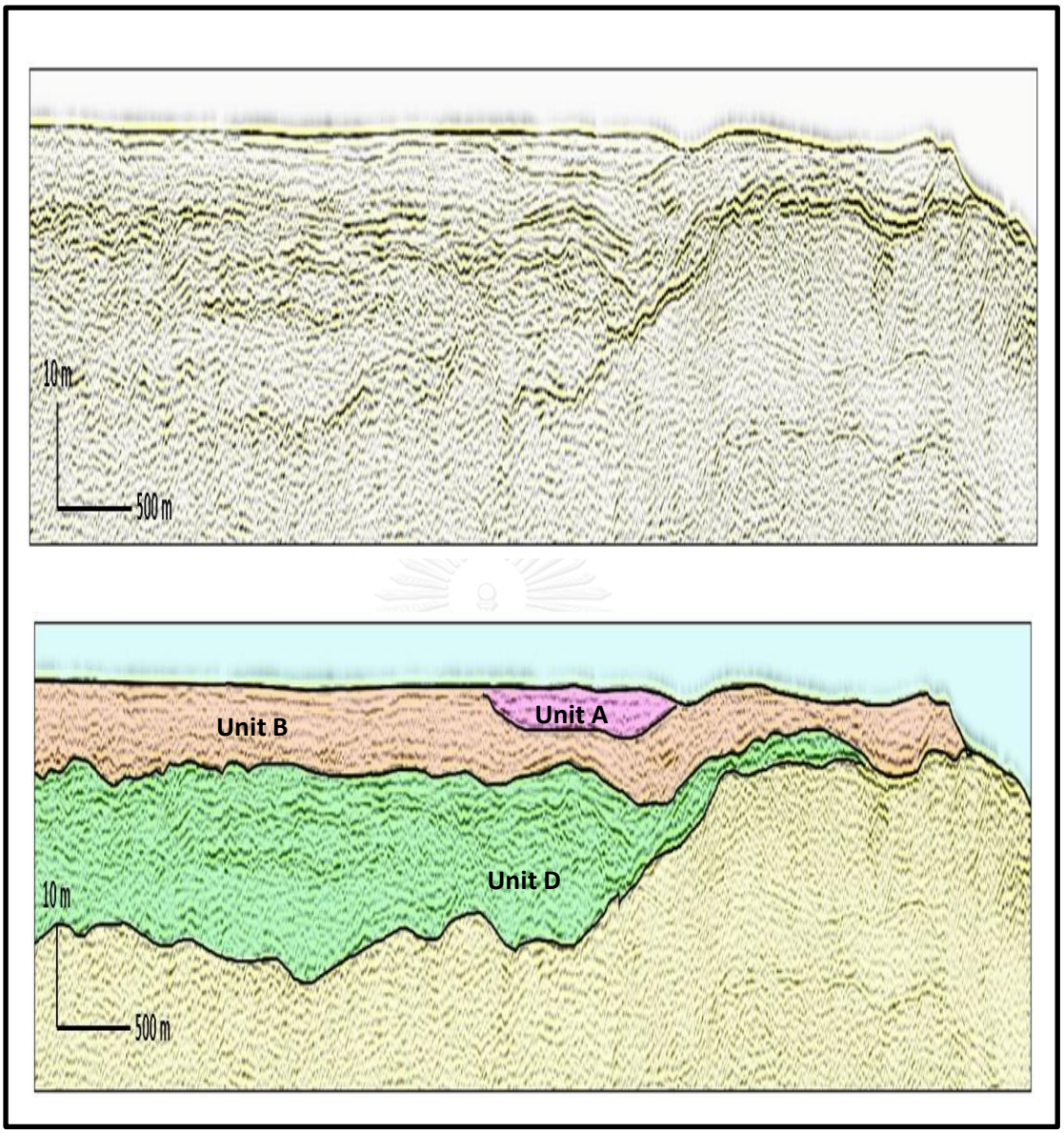


Figure 63 Cross section profile before and after the result of route 11th

Route 11th **(Fig.63-64)** that is from before and after of analysis of seismic with data logger is analyzed with interpreted. This line is long in the north and south way. This way is the longest way that has distant 11.8 kilometers. The data is rather cloud with data logging, so it combines with data logging to interpret precisely.

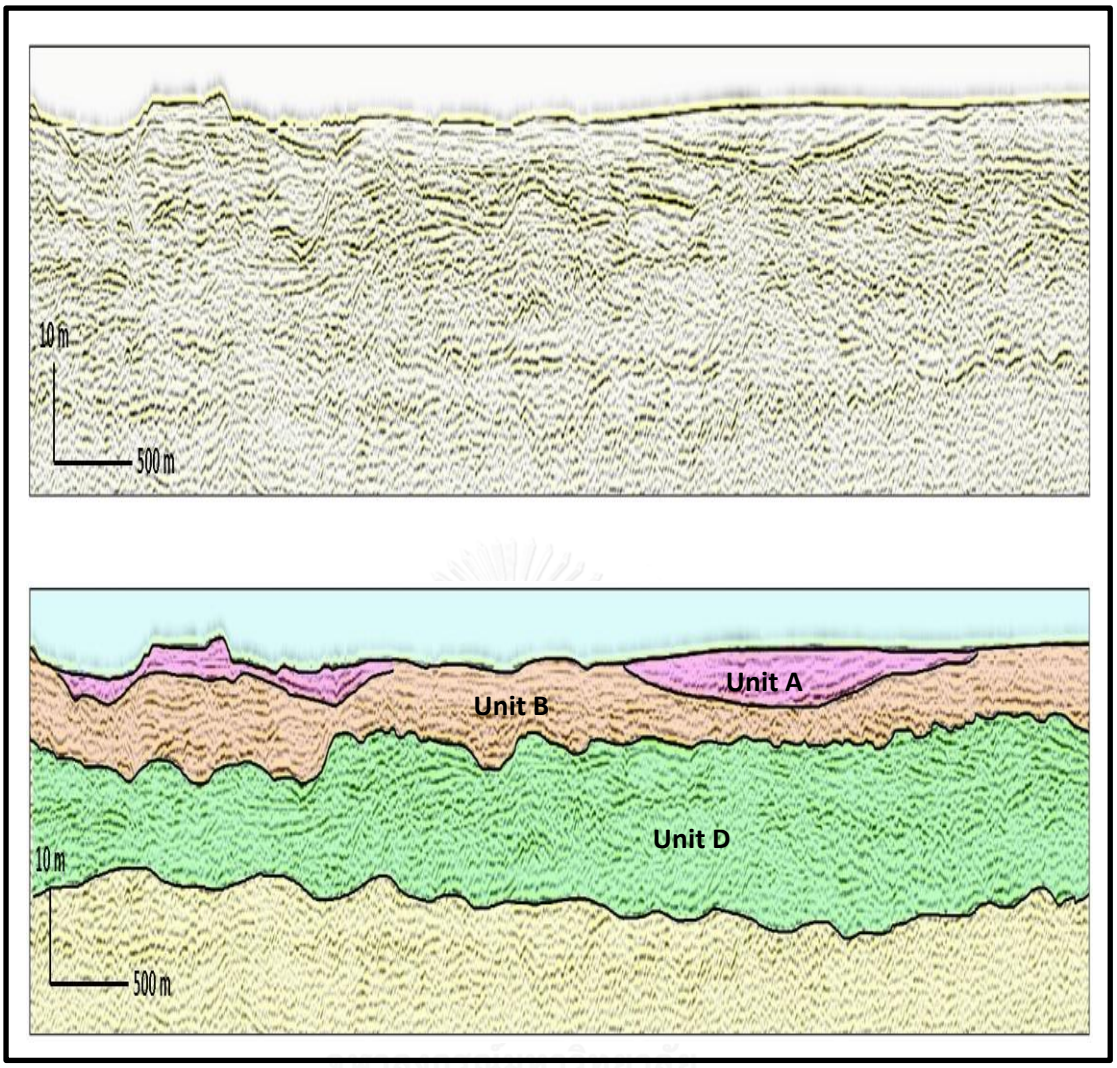


Figure 64 Cross section profile before and after the result of route 11th (continue)

Unit A which separates to be many pieces and thick about 2 - 7 meters is on the top. **Unit B** which is switched part with **unit A** is short area along the way. The thickness of sediment size is from the seabed around 8 - 10 meters. **Unit D** has a characteristic as arranged unit B which is thick in the north but slim in the south. There is 11 - 22 meters of sediment.

Chapter5

Conclusion and Discussion

5.1 The quality of resources obtainded from off Jomtien beach.

Primarily evaluated quality and quantity of reserved sand resources is studied from 6 boreholes of data logger and the analysis' results of seismic's distribution in a lab. There are the characteristics of the seismic levels. They are 3 main levels. 1) The upper sediment level is 0 - 2 meter depth from the sea floor that is a combination of clay layer in the sea nowadays. It's necessary to dredge on the upper level 2 meter. 2) The sediment is in 2-8 levels the sea floor. The sediment level combines with the paleo beach. From comparison of geological character during the Quaternary. The characteristics of this sediment level and the combination of sand with clay are light green with yellow. On the upper level, it may be found some shells. From the $D50^{th}$ sediment size distribution's analysis, it distributed between 0.33 - 0.42 millimeters or mean at 0.36 millimeters. However, the little sediment was washed out the floor sand and clay. $D50^{th}$ size of the dregs was distributing between 0.42 - 0.51 or mean has good quality to bring the reserved sand for beach nourishment is at 0.44 millimeters. 3) The sediment in level 8 - 12 m. is over the seabed. The sediment had ever been a part of the paleo beach too. The Quaternary geologies' characteristics had been estimated that it is about 8,000-9,000 years ago. The characteristics are sand with silt which is light olive-green to yellow. The distributing analysis of the $D50^{th}$ sediment on the upper level is between 0.33 - 0.4 millimeters or mean at 0.39 millimeters. The result is that the proper quality of reserved sand in this level is better than the upper level.

5.2 Comparison between seismic cross section profile with borehole data

Seismic cross section profile from the survey around study area combines with 6 borehole. This survey is to assess the characteristic of sand resources.

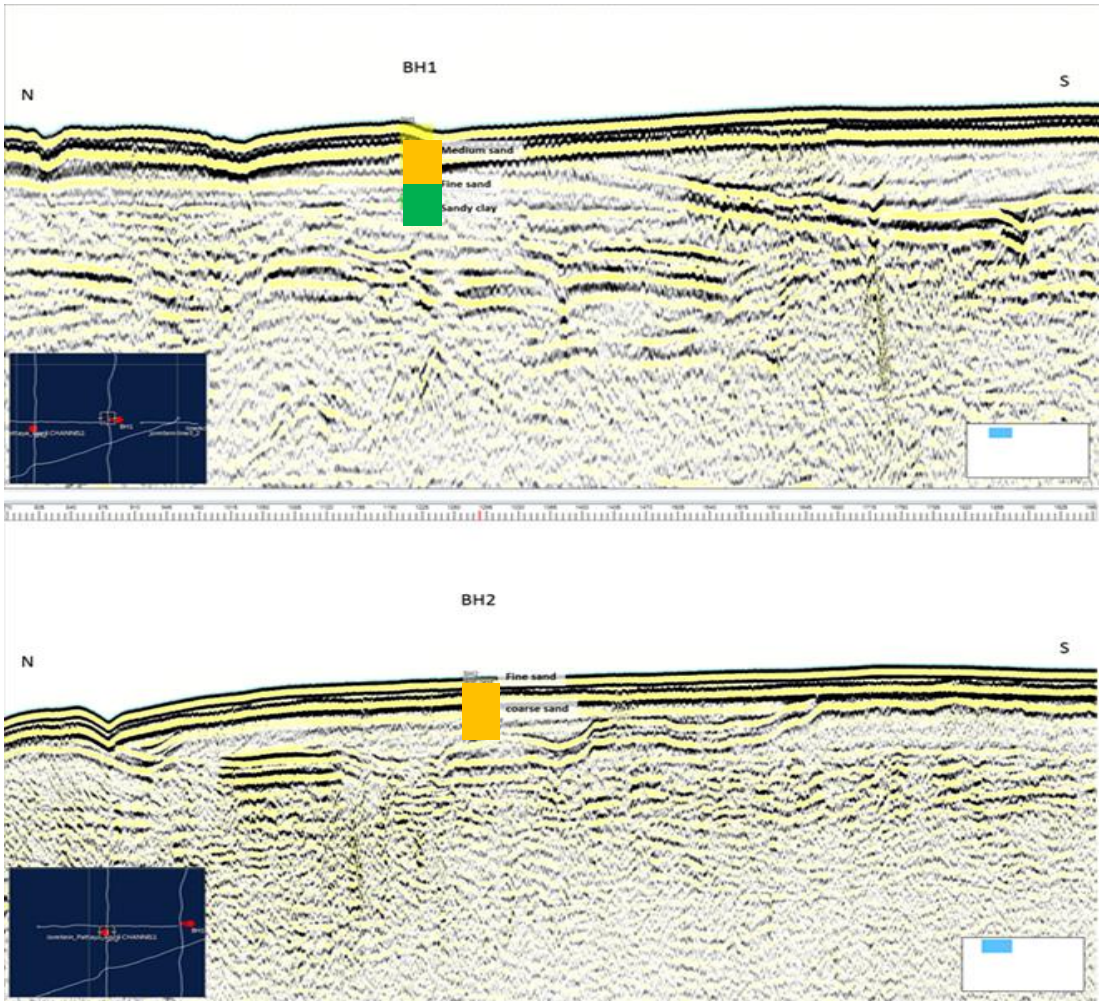


Figure 65 Seismic cross section profile overlaps with borehole BH1 and BH2

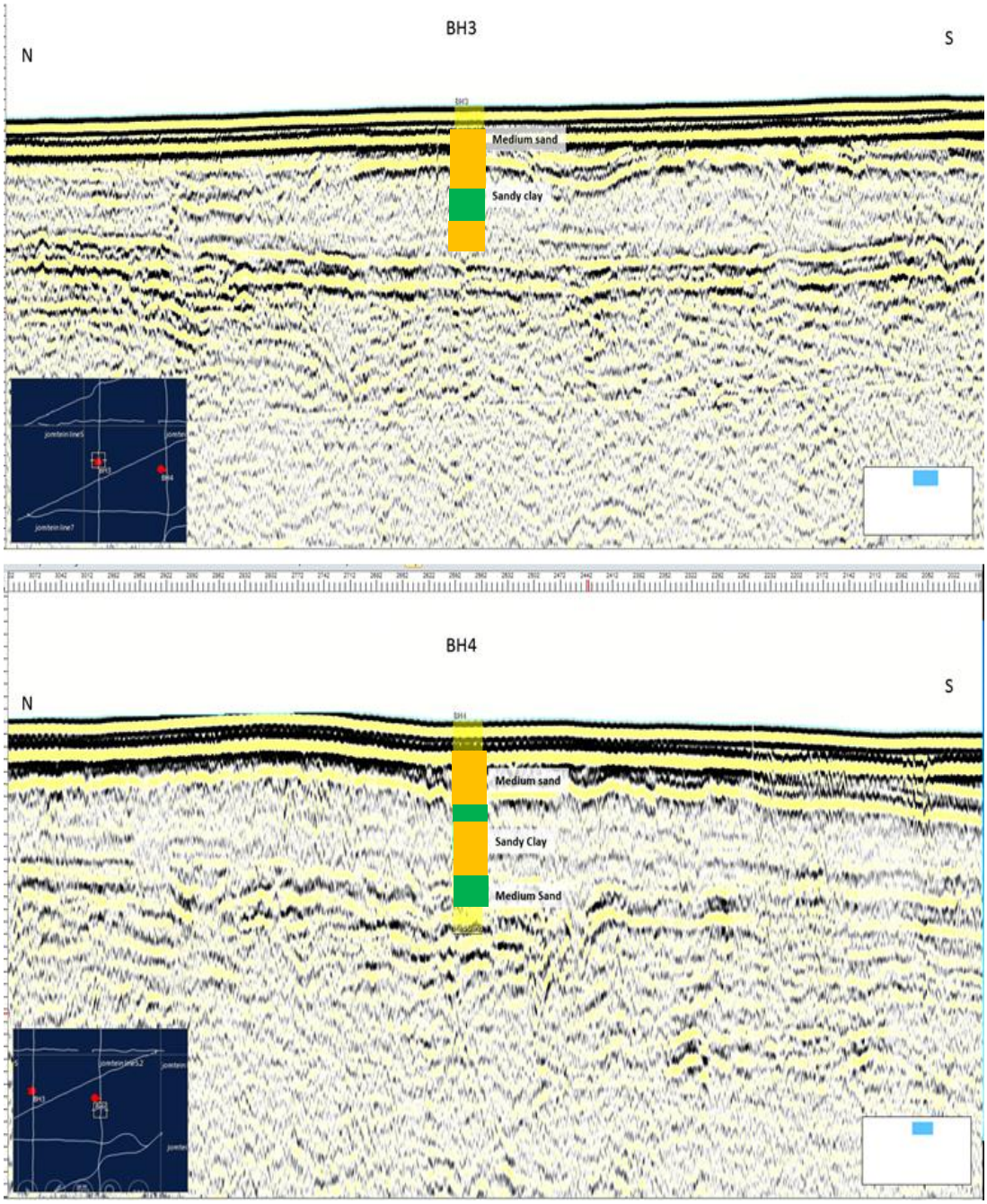


Figure 66 Seismic cross section profile overlaps with borehole BH3 and BH4

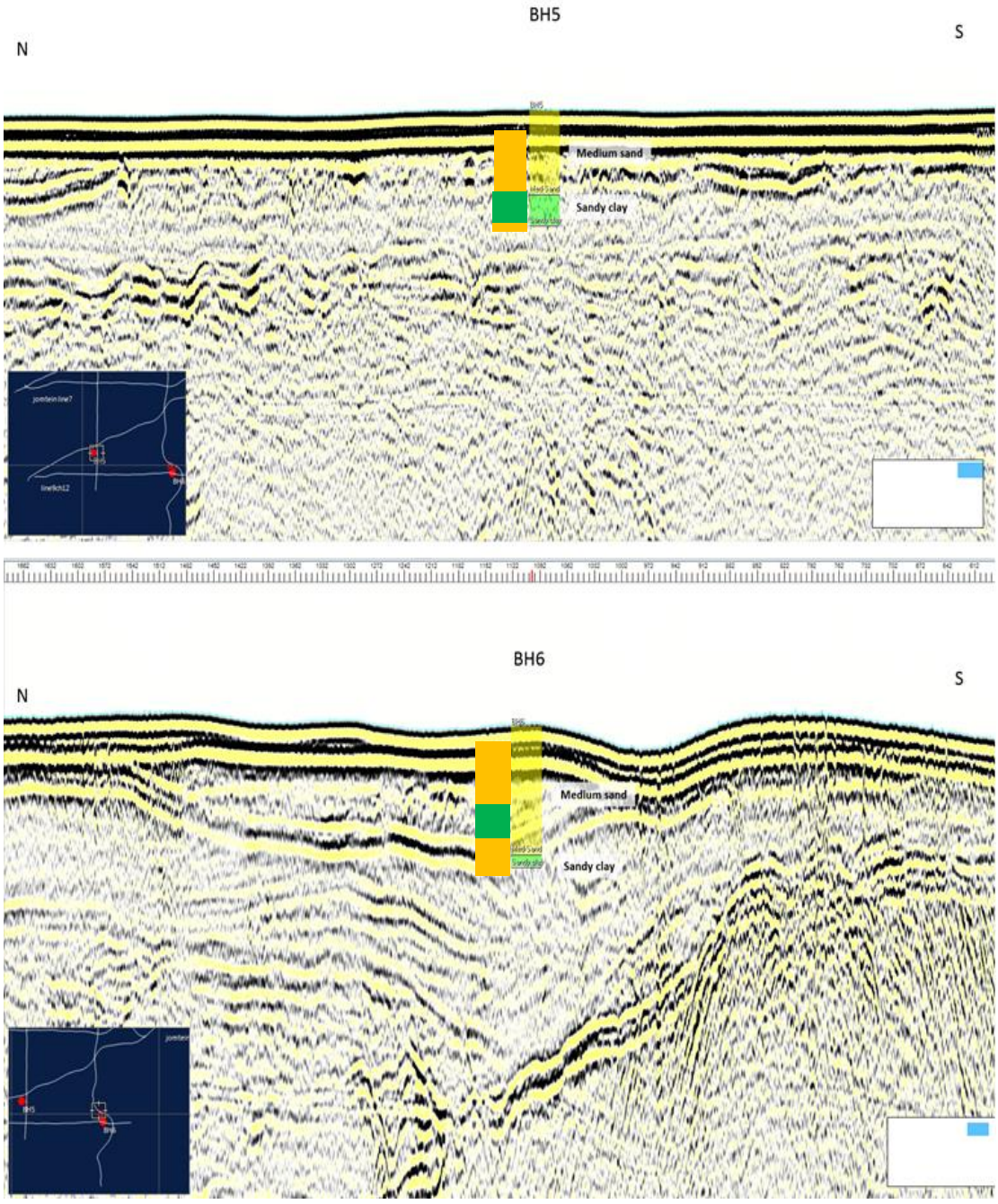


Figure 67 Seismic cross section profile overlaps with borehole BH5 and BH6

Figure 65, 66, 67 these show cross section of seismic survey lines by high resolution seismic reflection profile which was overlapped with data logger survey on the sediment levels in the sea. Following the borehole was numbered BH1, BH2, BH3, BH4, BH5, and BH6, so there are found all 6 holes. The depth from the seafloor is 5.45 meters until 11.50 meters.

5.3 Evaluation quantity of sand resources

Evaluation quantity of sediment layer is in studied areas. Data logger with seismic data is globally accepted evaluation. However there is limited of budget, it cannot evaluate the sand resources by data logger with seismic data. This research uses primary evaluation method which is widely famous. Method is borehole simulation from current boleholes' data that seismic data is like drilled hole. Borehole simulation stays every one kilometer. After that, it has calculated by Contouring with kriging method for the primary sediment resources in studied area as per below.

Unit A, thick sediment is about 3 meters that separate in the middle of studied area, and switch shortly with unit B. Quantity of primary evaluation is about 1.5 m3.

Unit B, thick sediment on the top is about 9 meters. Some area has been separated with Unit A shortly. There is evaluated primarily about 62.5 million m3.

Unit C, the characteristic is ancient channel in studied area. The width is around 400 meters. The deepest is around 12 meters. Quantity from primary evaluation is 20 million m3.

Unit D, it is on the lowest and thickest. The thickness is about 22 meters. The primary evaluation is 158 million m3.

In the conclusion, the quantity of sand resources outside Jomtien beach is from the seismic survey and interpretation with borehole data. It is evaluated primarily potential sediment resources in studied area about 242 million m3.

5.4 Evaluation of primary stratigraphy by statistics program (Rockworks)

Stratigraphy around survey area from the survey result becomes Fence diagram lithostratigraphy correlation model **(Fig.68)**. The study area is sand dune in the middle, and slope from the south to the north. The stratigraphy has taken from large to small particle size. On the top, it is marine clay in which was heaped normally environmental sediment.

The figure 68, showing the distributing evaluation of sand resources drilling is in every sediment levels under the sea. The 3D form shows the sequence of sediment and the arrangement of reserved sand. The same potential of the whole reserved sand area might calculate volume of the reserved sand with Rockworks program running by a contouring with kriging method. It was specified the gravity between 2.68 - 2.72 to sum up that is mean 2.7 (Bowles, 1979).

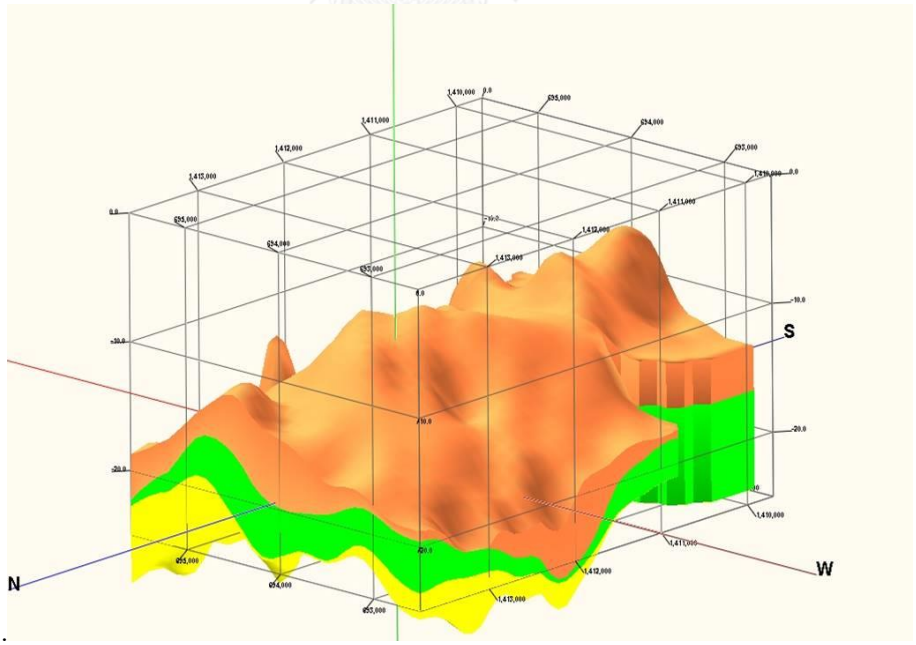


Figure 68 Evaluation of the sand resource is from the boreholes, and 3D form is an arrangement of potential with Rockworks.

5.5 Data of interesting 3rd route

1. The upper sand resources from the paleo-beach, and
2. The lower sand resources born from the paleo-river.

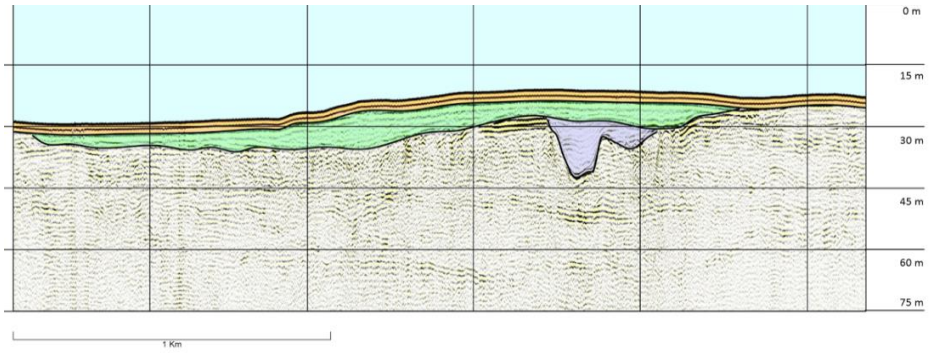


Figure 69 The 3rd route survey, cross section profile

The deep borehole in the upper sand resources' data logger which is from the paleo beach **(Fig.69)** was found a distribution of the sand resources. This is thick from 2 to 10 m. (logging). The width of the paleo beach estimates 2 kilometers, and the length starts from Lan island to Kram island.

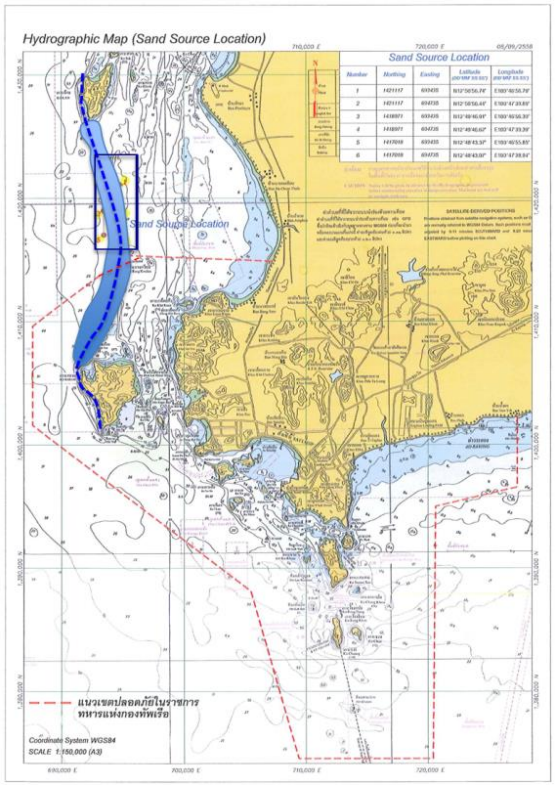


Figure 70 Upper sand resources bored from the paleo beach.

As the **figure 70** it shows the data of the whole cross section seismic profile that was interpreted. From the data, it can identify the lower sand resource as from the paleo river like the **figure 71.** The lower sand distribution was found that the paleo river line along with the north east to the south west. All 72 km^3 of survey area was found the paleo river is long 5 kilometers. The width is about 300 m., and the thick of this sand level is around 12 m. (seismic profile).

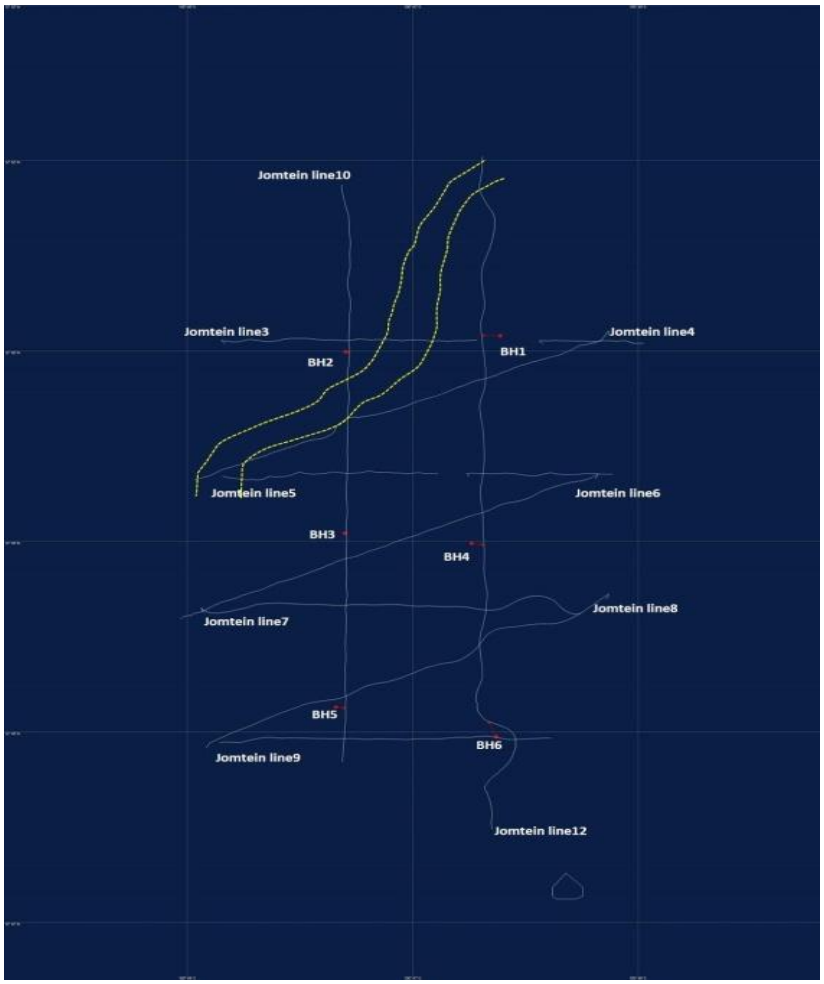


Figure 71 Lower sand resources bored from the paleo river.

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