CHAPTER II

THEORETICAL AND PROJECT BACKGROUND .

2.1 Analysis of subsurface depositional environment.

In the analysis of subsurface depositional environment approaches must be similar to those of the surface one using the following criteria to define sedimentary facies. (Selley, 1976)

a) Geometry,

b) Lithology,

c) Sedimentary Structure,

d) Paleocurrent, and

e) Fossils.

At the present moment oil companies have been using the vertical grain-size profiles as criteria for study the environment of deposition. By using Recent sediments in each environment as standard format of vertical grain size profiles (see from figure 4), analogous study can be applied to the interpretation of ancient sediments.

Vertical grain-size profile can also be studied from the geophysical log, additional to the lithologic logs. Geophysical logs that can be used to determine the grain size are the Spontaneous Potential

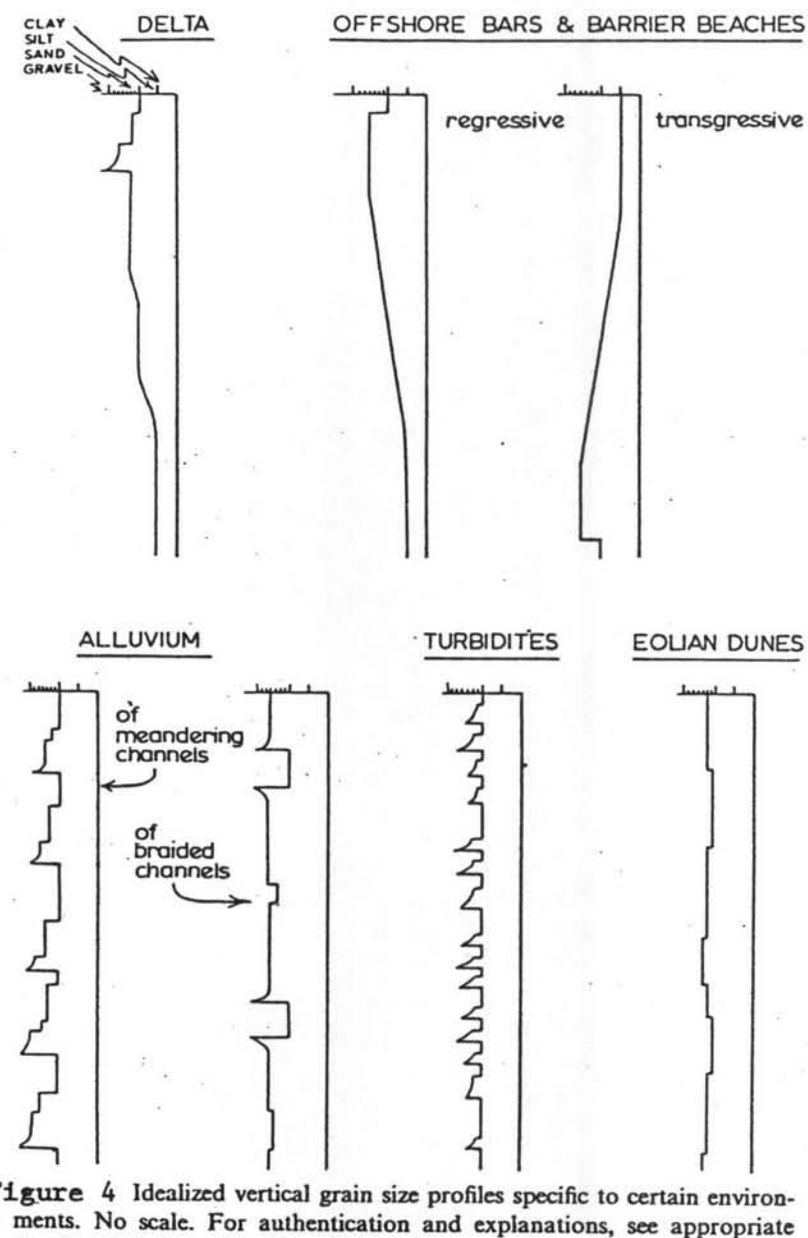

Figure 4 Idealized vertical grain size profiles specific to certain environments. No scale. For authentication and explanations, see appropriate chapters in text. (Selley, 1976) logs (generally abbreviated as S.P.) and the Gamma logs (generally abbreviated as G.)

First, the S.P. log will record the different value between the potential of an electrode moved along the borehole and the fixed potential of an electrode at the surface. The different value will change with cumulative effect of electro-filtration and electro-osmosis in the strata adjacent to the borehole. These parameters are essentially related to permeability. It is a general observation that shales are impermeable and that sands are permeable. Nevertheless, the permeability of sand will decrease when the grain size decreases (Pryor, 1973). Due to the fact that the amount of clay matrix increases when the grain size decreases, and these increasing matrix will undoubtedly inter the pore space of the sand grains. Hence, it can be concluded that the S.P. logs are directly relate to the permeability and the permeability are ultimately related to the grain size. On this basis, the S.P. logs may be used as a continuous vertical grain size profiles.

Selley (1976) has demonstrated that S.P. logs can be used to illustrate good vertical grain size profiles for sediments that have 2 characteristics :

1) For sediments that only have primary intergranular porosity.

2) S.P. curve only shows good amplitude when there are a substantial difference between the salinity of the drilling mud and that

of the formation waters. For a number of reasons S.P. curves of offshore wells seldom show sufficient amplitude to be used as grain size profiles.

Second, the Gamma logs that show the radioactivity of the formation and this value is directly related to the amount of clay present. If sediments contain large amount of clay then the gamma log will show high value. Therefore gamma log is related to grain size that is the value of gamma log decreases with the increasing grain size. For this reason gamma logs may be used as a continuous vertical grain size profile too.

The gamma tool, like the S.P. log, has several limitation in the usage (Selley, 1976). The value measured is also affected by the hole diameter and may produce a relative low reading value where there is extensive caving. Besides, the problem might occur due to the presence of radioactive minerals other than those present in clays.

2.2 Self Potential log models used in depositional environment interpretation.

The depositional environment can be deduced from the Self Potential log motifs as illustrated in Figure 5

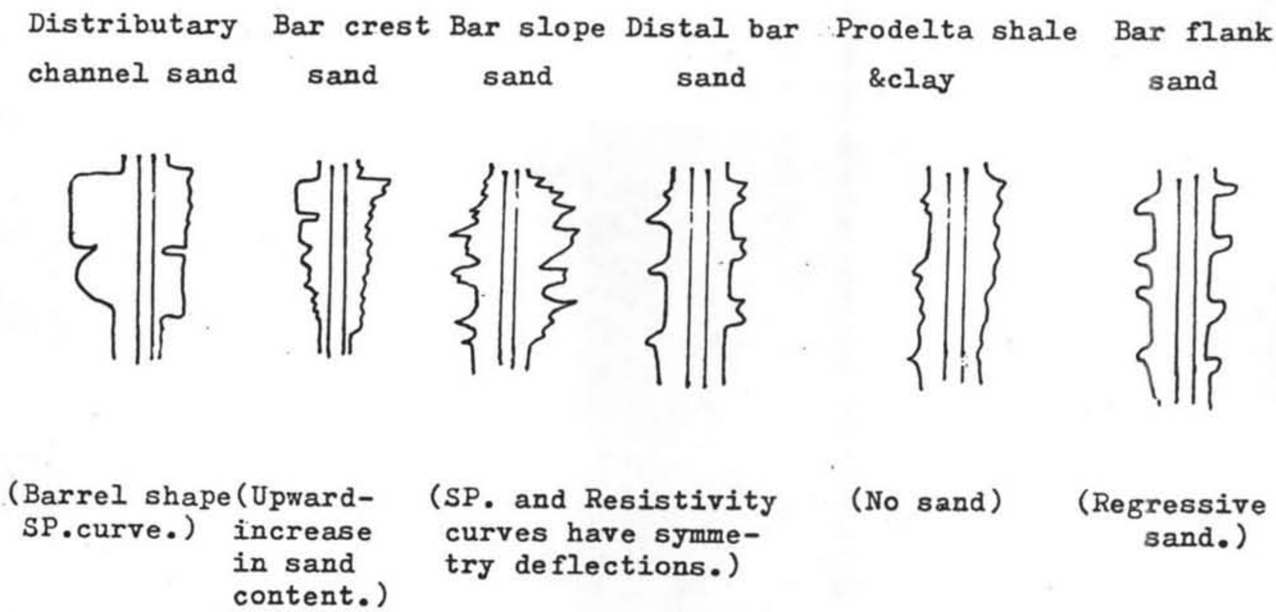

Figure 5-1 Theoretical sedimentation patterns of delta recognizable from SP. curve shapes. (Fisher, et. al., 1969)

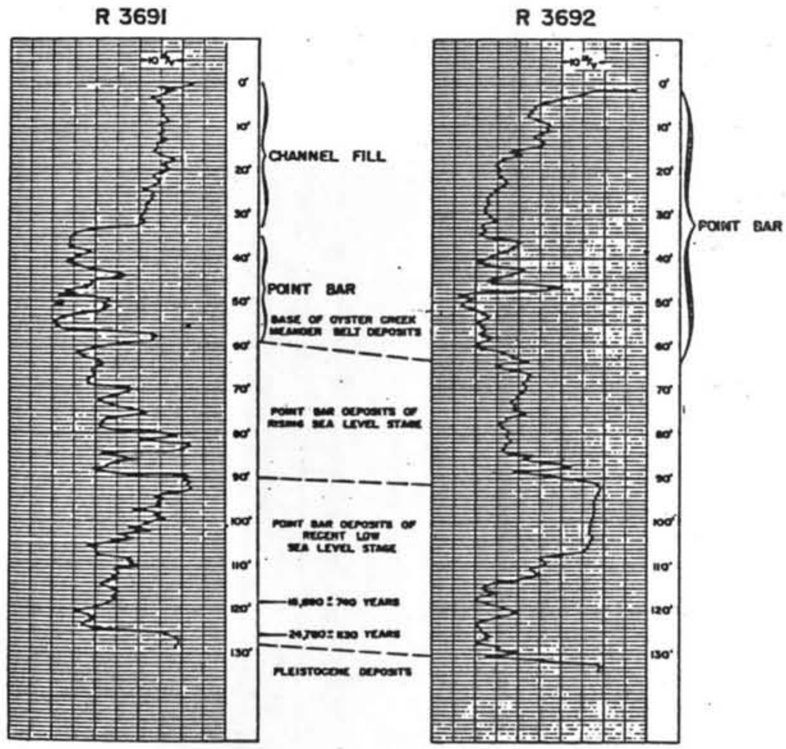

Figure 5-2 SP. logs of channel fill and point bar deposits, Holocene Brazos River showing control of veritcal sequence on SP. properties (Fisher, et. al., 1969)

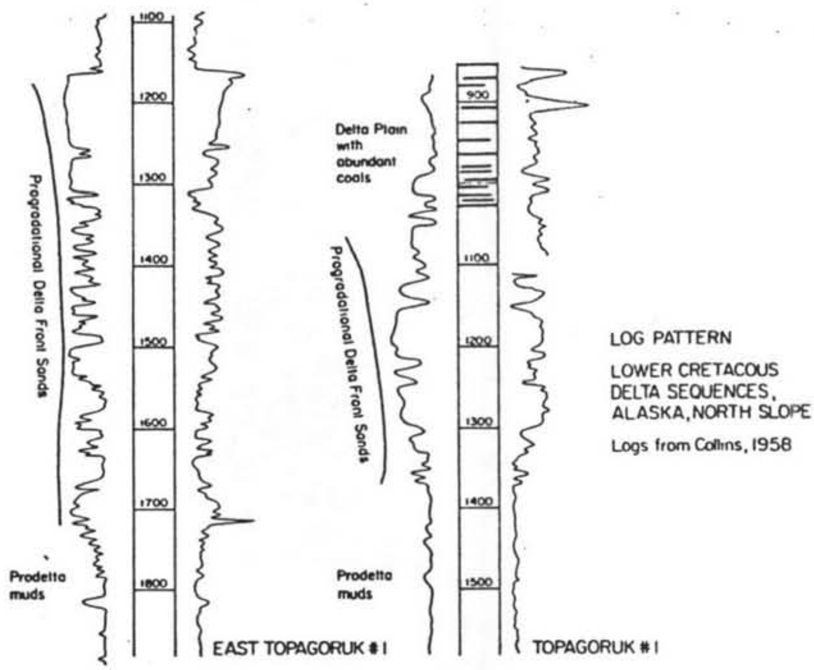

Figure 5-3 Typical E-log patterns of Cretaceous North Slope deltaic sands. Compare with E-log patterns of Gulf Coast Basin deltaic sands (Fisher, et. al., 1969)

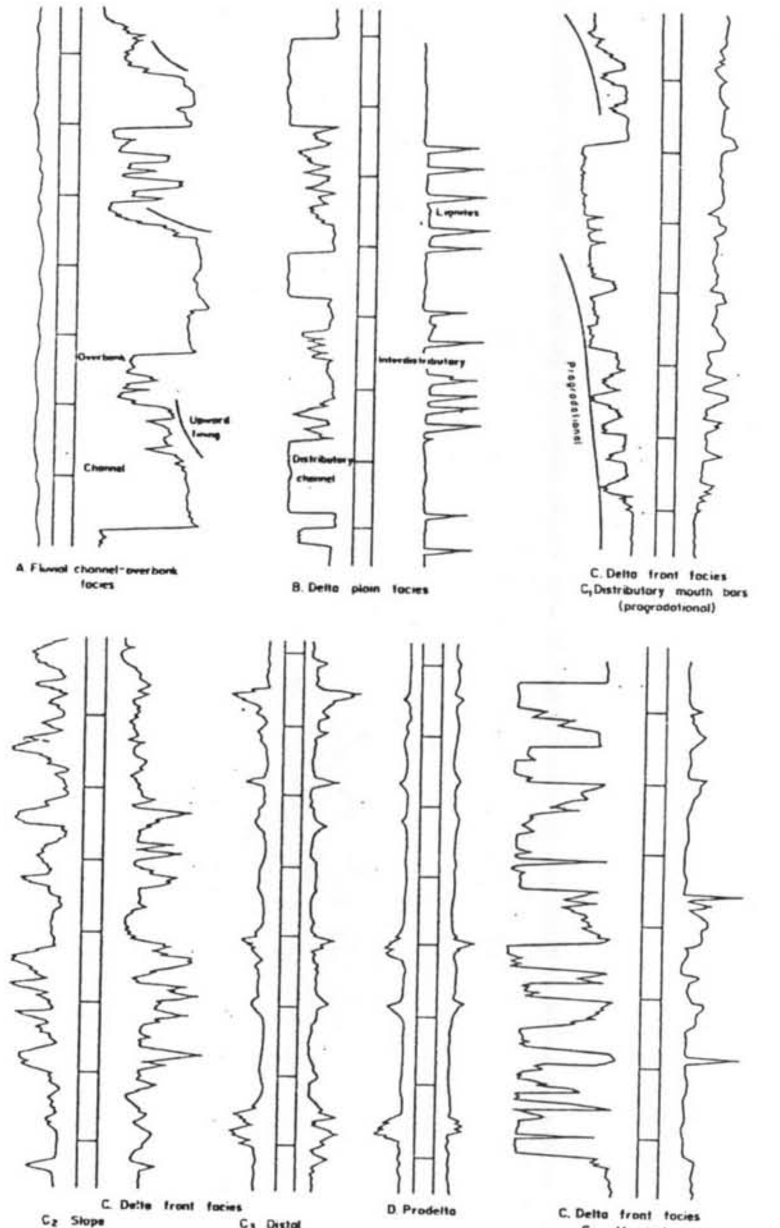

Figure 5-4 Representative E-log patterns, high-constructive lobate delta systems, Gulf Coast Basin. (Fisher, et. al., 1969)

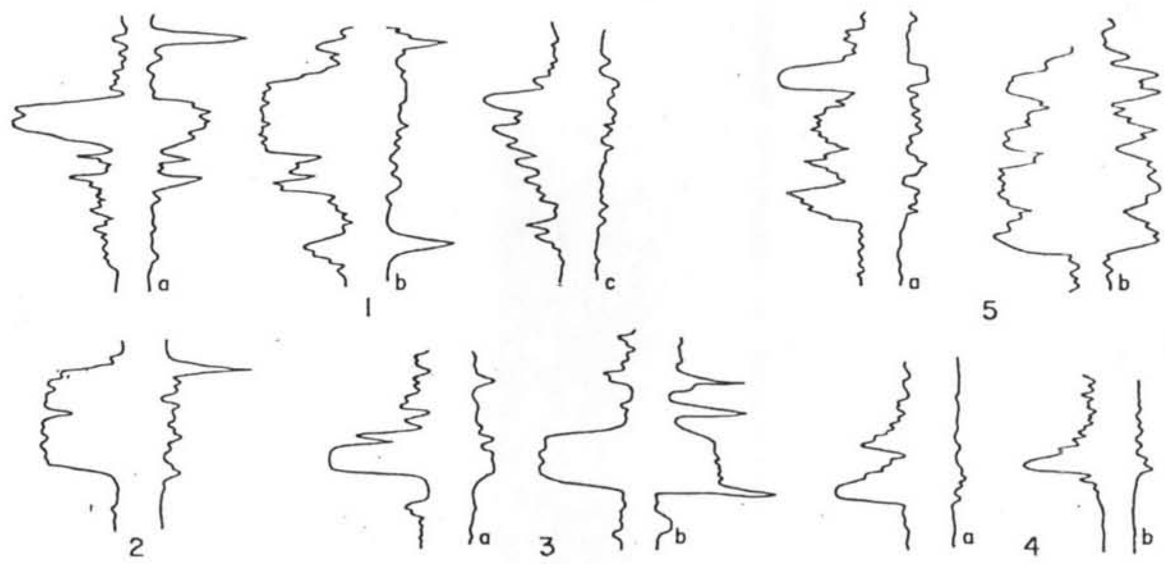

Figure 5-5 Characteristic electric log patterns of Cisco sandstones. (1) Progradational distributary mouth bar and distributary flank-delta front sands. a. Prodelta and distal bar capped abruptly by massive bar crest and distributary channel sand. b. Thin prodelta sequence capped by bar and distributary fill. c. Prodelta mud capped by thick sequence of bar flank sands. (2) Distributary channel fill capped by thin calcareous destructional sheet. (3) Delta plain aggradational channel-fill sandstones charcterized by abrupt lower boundaries and blocky S.P. patterns. Channeling into underlying facies, including limestones, is pronounced. (4) Delta plain aggradational channel fill characterized by abrupt erosional lower boundary and fining upward sequence. (5) Multistory sands. a. Progradational sequence of distributary mouth bars capped by massive distributary fill. b. Superposed aggradational channel fill of types 3 and 4. (Fisher, et al., 1969)

2.3 Stratigraphic correlation

In determining the lithological correlation between primary and secondary wells, the following 3 criteria are employed.

1) Depth,

2) Lithology, and

3) Law of Superposition and Original Horizontality.

2.3.1 Depth

Previous investigations by many workers on the groundwater potential of Bangkok Metropolis and neighbouring area have come to a similar conclusion. There appears to be 4 aquifers within depth range of 0 - 250 meters. Details regarding the characteristics of these aquifers are summarized and presented in Table 6 and Figure 6.

2.3.2 Lithology

Within the study area, there are 2 major kinds of lithology, sand and clay that directly related to the grain size characteristics and permeability. Generally, sands are permeable and shales are impermeable strata, but the permeability of sand will decrease when grain size decrease. Besides, there are some minor kinds of lithology that are the mixtures between sand and clay. These mixtures alternate with sand and clay in almost all places.

Table 6.: Aquifer Description (after METCALF & EDDY INC, 1977)

Aquifer	Depth to Top of Aquifer Meters	Total Thickness Meters	Description
Bangkok Upper (30 meter)	20 to 30	< 1 to 30	Fine to coarse sand with gravel. Directly underlies Bangkok clay in most places. Aquifer missing in some areas or too fine grained to be a source of supply.
Bangkok Lower	30 to 50	< 1 to 50	Predominantly fine to coarse sand with gravel and clay layers. In many places directly interconnected with 30 meter aquifer. Both aquifers also referred to as the Bangkok aquifer.
Phra Pradaeng (100 meter zone)	60 to 100	< 1 to 70	Fine to coarse white sand with gravel and clay layers. In some places directly interconnected with the 50 meter aquifer. Occasionally missing in the eastern and western parts of the area.
Nakhon Luang (150 meter zone	110 to 160	< 5 to 70	Fine to coarse sand and gravel interbedded with clay layers which are locally extensive. Individual sand layers up to 30 meters thick.
Nonthaburi (200 meter zone)	180 to 200	< 5 to 60	Fine to coarse sand and gravel layers interbedded with clay and silt.
Sam Kok (250 meter zone)	240 to 250	10 to 55	Sand and gravel layers interbedded with clay.
Phya Thai (350 meter zone)	295 to 320	10 to 40	Sand and gravel layers interbedded with clay.
Thonburi (400 meter zone)	350 to 435	50 to 110	Sand and gravel layers interbedded with clay. Aquifer section may contain several distinct water bearing zones.
Paknam (550 meter zone)	530	30	Variable thick layers of sand and gravel interbedded with clay. Individual and layers as little as 5 meters thick.

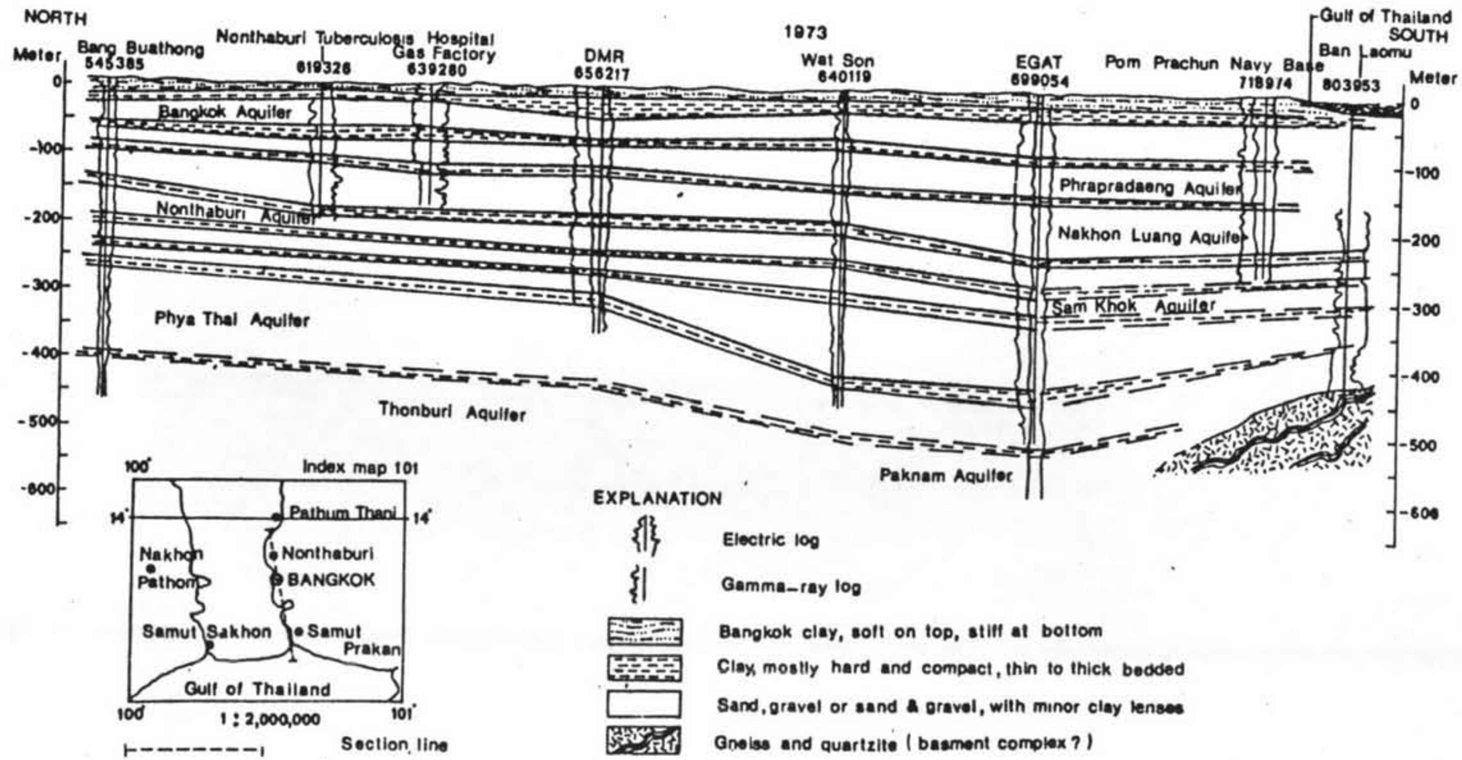

Figure 6 Hydrogeologic N–S section of the lower Chao Phraya Delta showing principal aquifers of Bangkok Metropolis (correlated by electric and gamma-ray logs). (Piancharoen and Chumthaisong, 1976).

On the basis of the lithological characteristics of aquifer particularly regarding the permeability, sediments of Group I can be correlated with all other possible sediments consisting of sands as the major grain constituents and gravels, silts or mixtures between these two as minor grain constituents. In the same manner, sediments of Group II can be correlated with all other possible sediments consisting of clay as the major grain constituents and silts including mixed sediments as minor grain constituents. This conceptual approach is summarized and presented in the next page.

2.3.3 Law of Superposition and Original Horizontality (Nicholaus Steno's)

After Piancharoen and Chuamthaisong (1976), the Lower Central Plain is a geological depression filled with alluvial and deltaic sediments since Tertiary time. And Kulsingha (1979) stated that Tertiary rocks have their depositional history extended to the Miocene Epoch. The tectonic movements in the central part of Thailand which were essentially responsible for the formation of the great depositional basin terminated at the end of Miocene. Therefore, sediments infilling the depression of central Thailand are believed to be of post-Miocene in age.

The aeromagnetic data indicate that the depth of basin ranges from 400 to 3,500 meters and it's floor is generally sloping towards the central axis which is located more or less along the Chao Phraya River Course and inclined southward to the Gulf of Thailand. (Achala--bhuti, 1974)

	Group I Permeability (should be aquifer)			Group II Impermeabiligy (should not be aquifer)	
Major		SAND (S)		CLAY (C)	
Minor	Gravel (G)	mixed sediments	Silt (Z)	Silt (Z)	mixed sediments
		silty Gravel (zG) *sandy* Gravel (sG) *silty* Sand (zS) *gravelly* Sand (gS) *sandy* Silt (sZ) *gravelly* Silt (gZ) *clayey* Gravel (cG) *clayey* Sand (cS)			*gravelly* Clay (gC) *silty* Clay (zC) *sandy* Clay (sC) Mud (M) *clayey* Silt (cZ) *sandy* Silt (sZ)

It can be concluded that Bangkok Area which is in the southern part of the Lower Central Plain and lies on the central axis (Figure 3) should have the depth of basin floor greater than 400 meters filled with sequence of sediments. The sediments must have been deposited from Miocene Epoch onward after the last tectonic movement.

Basides, cuttings from groundwater wells (drilled depth 0-250 meters) reveal that the sediments are unconsolidated. This should indicate that sediments are possibly younger than Miocene Epoch age.

Clearly the topography of bedrocks of the sedimentary basin has very little to no influence on the control of depositional nature of the younger sediment deposited in the upper part of the sequence. Hence, deposition of sediments in the upper part follows the Law of Original Horizontality and the Law of Superposition stated by Nicholaus Steno. The various aquifers of Bangkok Metropolis in Figure 6 illustrate that all sand layers appear in a horizontal and sub-horizontal layer throughout the area. However, it is interesting to note that the uniformity of the aquifers in terms of their geometry according to Piancharoen and Chuamthaisong, (1976) is very unusual and highly speculative for such a large scale coverage.

2.4 Previous works

According to Brown et. al. (1951), Pendleton (1962) and Cox (1968), the head of the gulf of Thailand covering the area of Bangkok Metropolis is a major site of deltaic sedimentation and the land is growing seaward at an estimated rate of 4.6 to 6.0 meters/year. The initial growth rate of the Chao Phraya delta was estimated by NEDECO (1965) to be 70 meters/year.

Sodsee (1978), divided the Chao Phraya Basin into seven regions geohydrologically. There divisions are based on the aquifer characteristics. The description of these regions are shown in Table 7 and the geological cross-sections are given in Figure 7 - 10.

According to Achalabhuti (1974), sediments of the Chao Phraya Basin and the Gulf of Thailand were laid down at the same geological time. Evidences from oil wells in the Gulf which penetrated sedimentary sequences show the ranging in age from Recent to Oligocene. Besides, after Piancharoen and Chuamthaisong (1976) water wells in Bangkok Metropolis Area at the depth exceeding 600 meters concluded that there are at least three major breaks of deposition. These are indicated by the differences formation composition, geoelectrical properties and water quality. Sedimentary sequences accumulated during the Pleistocene Epoch have been found to be thickening southward and southwestward. In Pathum Thani area, the depth to the bottom surface of Pleistocene sediments started at about 256 meters while in the Phra Pradaeng and Nong Khaem areas, they can be found at the depth about 420 meters. (Table 8 and Figure 6).

From a detailed study of electric and lithologic logs of groundwater wells, the Department of Mineral Resources has identified and named eight aquifers within the 550 meters depth (Table 6). These

Table 7 : Geohydrological Regions of the Lower Central Plain (after SODSEE, 1978)

Region	Depth to Bed Rock (m)	Extent	Description
Chao Phraya Trough	70 to 2,000+	Area both sides of the Chao Phraya River	Sediments several hundred meters thick with aquifers (6-50 meters thick) interbedded
Chacheong Sao Terraces	20 to 100+	Chachoeng Sao Province near the Bang Pakong River	Two thin aquifers (2-10 meters thick) interbedded in thick clays
Khorat Aprons	1 to 100	Along the border of Khorat Plateau	Marl, clay and sandy gravel lenses with some lateritic sediments
Rat Buri Terraces	160+	Area in between the Mae Klong and the Tha Chin Rivers	Several aquifers (4-20 meters thick) interbedded with clay, thicknesses and sizes of sediments decrease from north to south
Tak Fa Alluvial Fans	15 to 120+	East of Nakhon Sawan	Thick lateritic clay with only one thin sandy gravel aquifer (10-15 meters thick)
Tanaosri Piedmont	5 to 160+	West bank of the Tha Chin River in Suphan Buri and Kanchanaburi Provinces to the mountain foot-hills	Thick clay with thin sand and gravel lenses (4-30 meters thick)
Uthai Thani Terraces	4 to 80	Uthai Thani, part of Chainat and west of Nakhon Sawan Province	One aquifer (10-45 meters thick) directly overlying bed rock, some limonitic and lateritic sediments (20-40 meters thick)

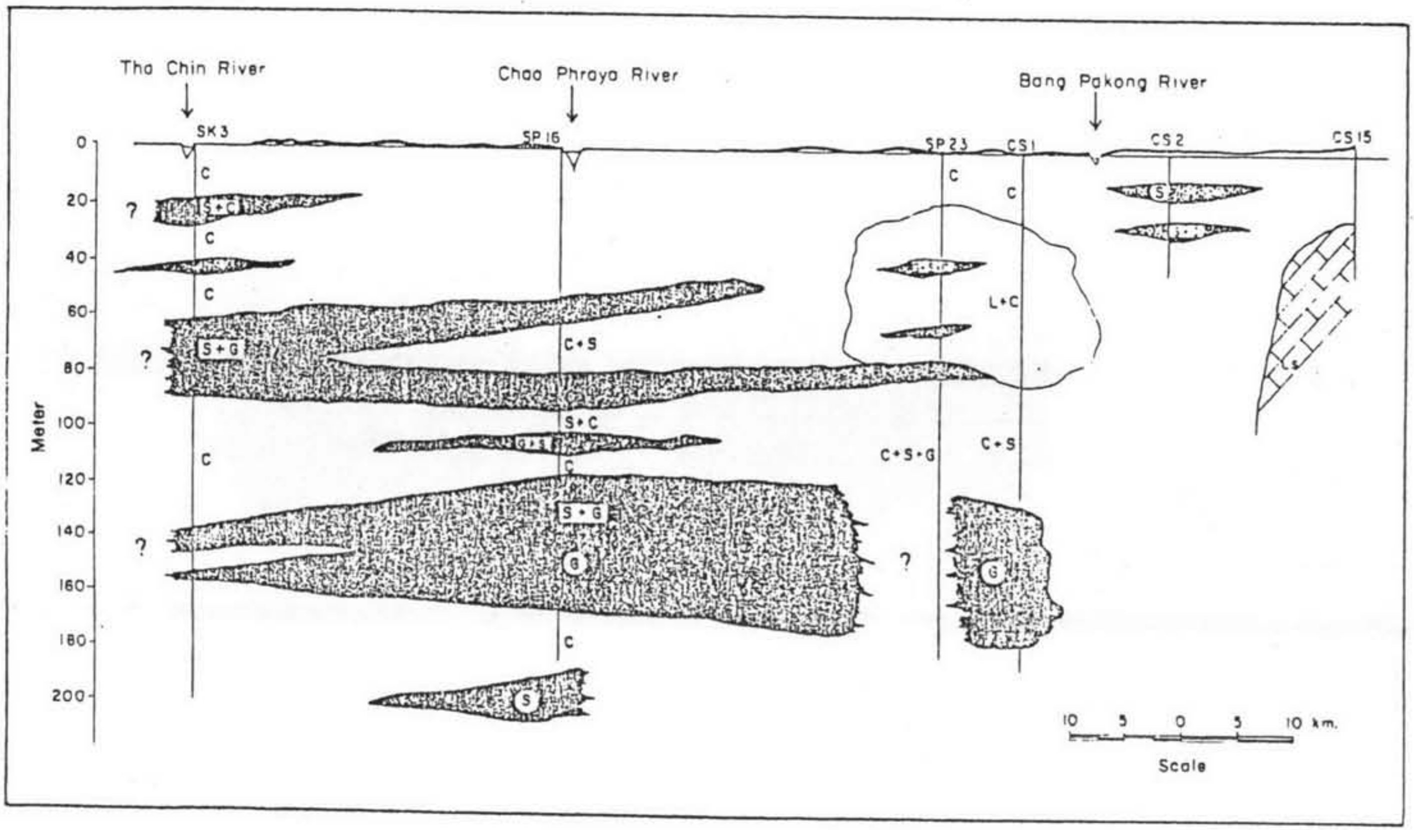

Figure 7 Geologic Cross-Section of the Area near the Gulf of Thailand (SODSEE ,1978)

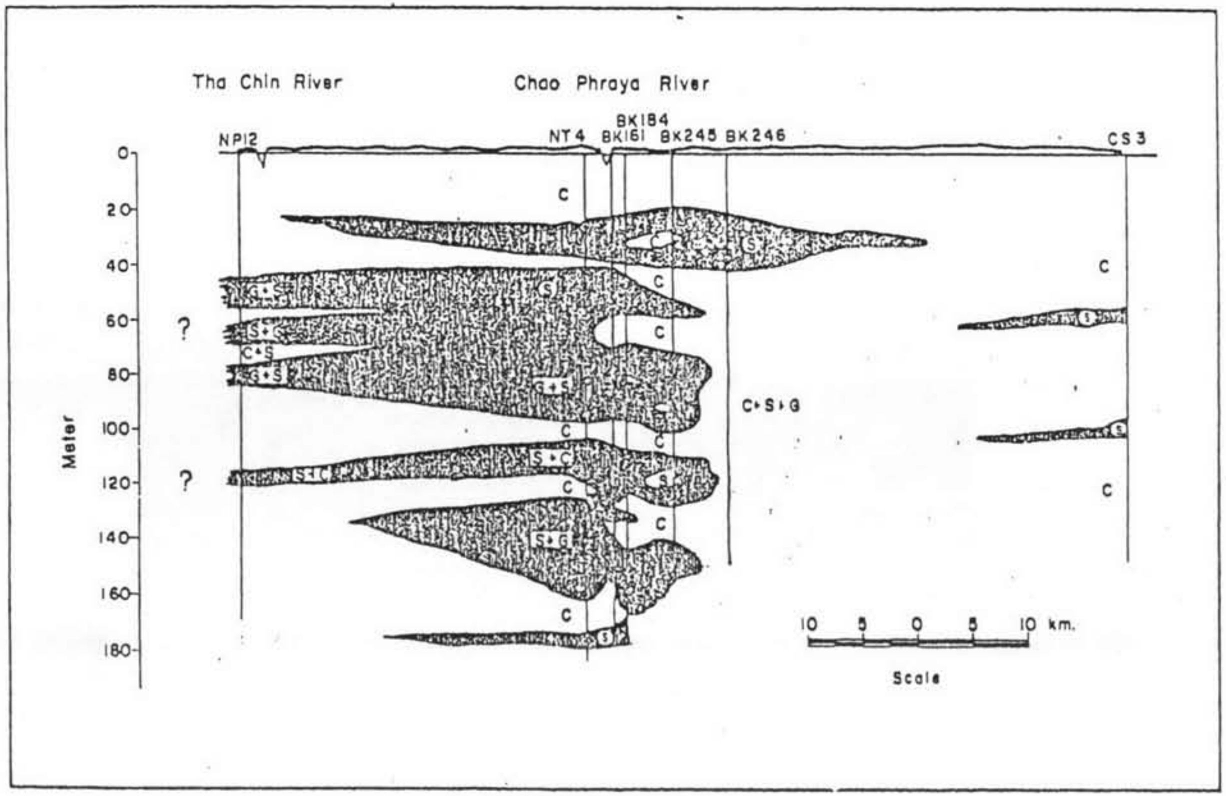

Figure 8 Geologic Cross-Section of the Nonthaburi-Bangkok Area (SODSEE, 1978)

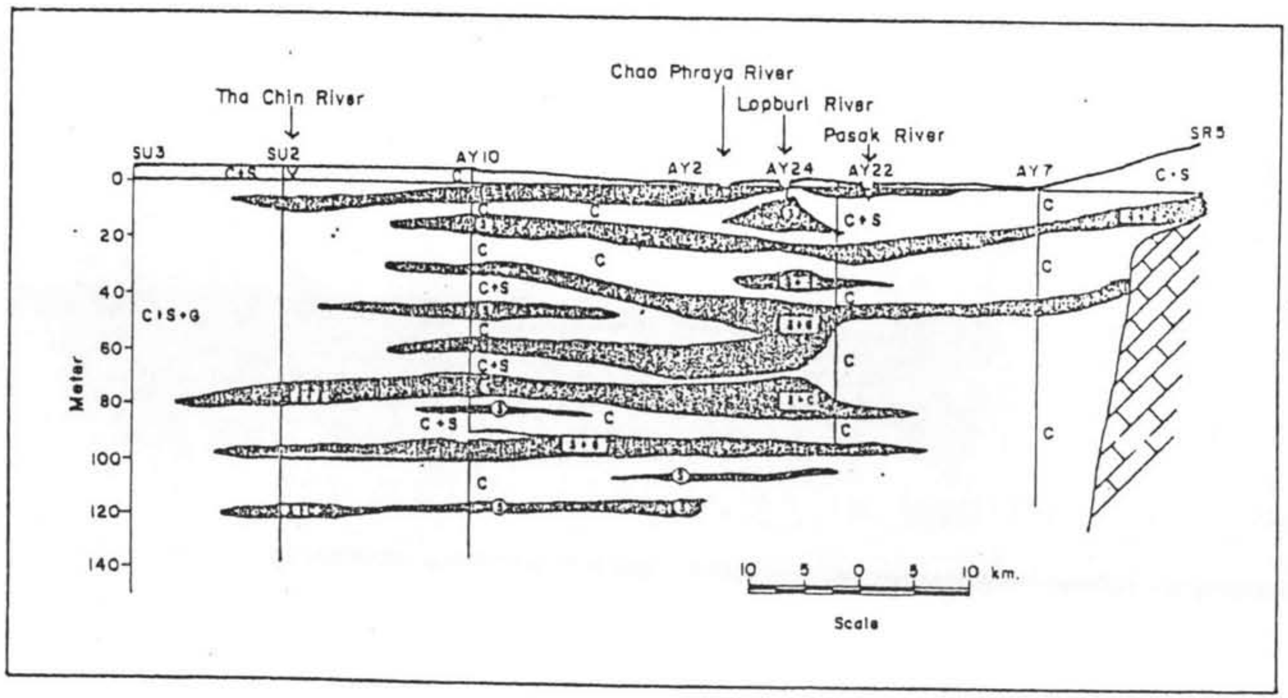

Figure 9 Geologic Cross-Section of the Ayutthaya - Angthong Area (SODSEE, 1978)

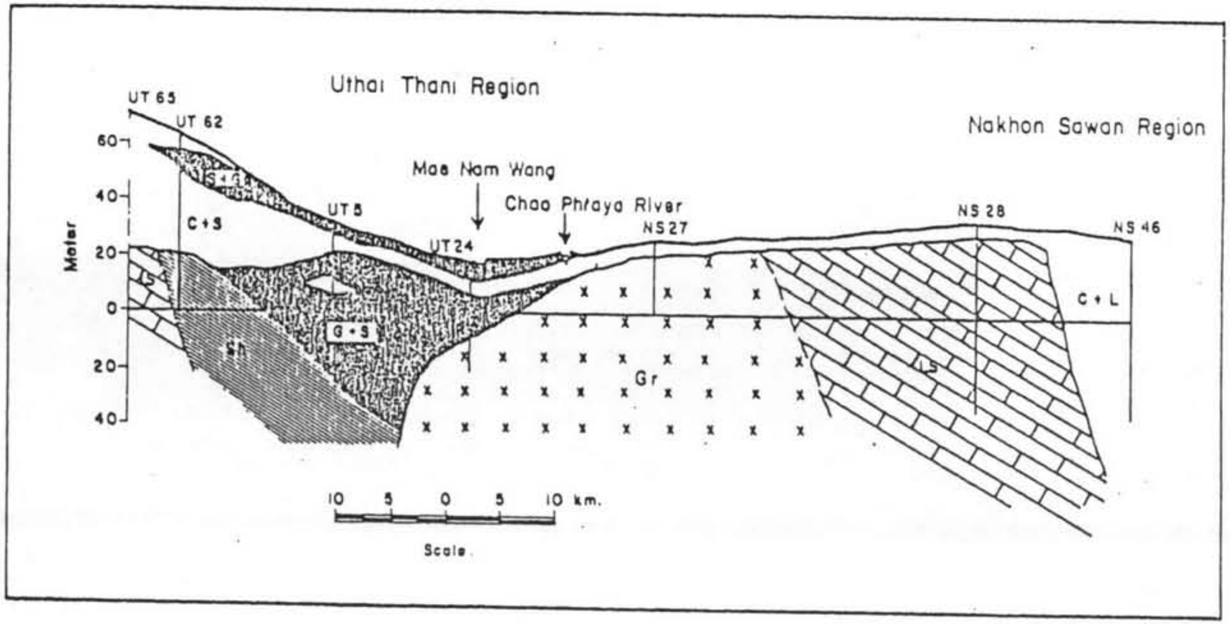

Figure 10 Geologic Cross-Section of the Uthai Thani - Nakhon Sawan Region(SODSEE , 1978)

Table 8 : Three major breaks in deposition of sediment at Bangkok Metropolis (Piancharoen and Chuamthaisong, 1976)

	Depth (m)	Lithology	Depositional environment	Age
Bangkok-Clay	> 0 < 30	Soft to stiff dark gray to black clay, saturated by brine or salt water with Recent shell fragments	sea transgression based on transgression of SP curves (Pirson, 1970)	post-glacial-time
Unit 1	730 < 100	Two sequence of medium to thick sand and gravel layers with minor clay lenses, separated by a distinet clay bed. It consist of poorly to moderately sorted, medium to coarse sand with a typical thick sand-and gravel bed very coarse grained at the lowest part. The carbonized woods or logs were always found in it. Colour is generally light gray but in places yellowish due to oxidation.	Fluviatile and Delta (Based on the oxidizing character and the presence of both salty and fresh water)	Upper-Pleistocene.

Table 8 (cont.)

	Depth (m)	Lithology	Depositional environment	Age
First break	100	Yellowish brown compact clay	(?) Sea transgression	
Unit 2	>100 <400 or <250	Ratio between clay/sand-gravel is about 1:3. Clay is light brown to yellowish brown, usually stiff, normally sandy, gravelly in places. Fragments of shells are present in some clay lenses. Beds of sand-gravel are generally thick, ranging from 10 to 25 meters. The sand-gravel is characteristically light brown to dirty brown, becoming white in clean and well sorted layers, subangular to subrounded, generally moderately to well sorted.	Fluviatile (Based on freshwater and locally brachish to salty water their geolectrical properties.	Lower--Middle Pleistocene

Table 8 (cont.)

	Depth (m)	Lithology	Depositional environment	Age
Second break	250 in northern parts of Bangkok and 400 meters near the Gulf			
Unit 3	> 250 or > 400 and < 600	Well sorted medium to coarse sand with occasional gravel. Beds of sand are commonly thick. Intercalated clay is generally sandy, having characteristics of claystone instead of ordinary clay. Colour is pinkish brown to grayish brown, and olive gray glauconitic colour in some place.	Fluviatile and Fluviomarine (Based on reddish brown sand, pinkish to reddish brown clay and olive gray glauconitic colour clay)	Pliocene
Third Break	600			

aquifers consist mainly of sand and gravel separated by virtually impervious strata of clay (Ramnarong, 1976; Metcalf & Eddy, 1977). However, where these layers are absent, direct hydraulic interconnection exists between adjoining aquifers. Based on the water quality and the hydraulic aspects of the aquifers, there are evidences to believe that the Phra Pradaeng, Nakhon Luang and Nonthaburi aquifers are interconnected (Metcalf & Eddy, 1977).