CHAPTER 1

INTRODUCTION

1.1 Introduction

Geological structures are important in petroleum exploration. Faults and folds are responsible for trapping oil and gas. The petroleum industry uses a variety of sophisticated techniques to probe the subsurface, including exploratory drilling that can determine rock types and bedding orientation several kilometers below the surface, and seismic reflection profiling that determines large-scale relationships below the surface.

The study area is located in the Arthit Concession, on the northwestern margin of the Malay Basin. The basin is an intracratonic basin formed by rifting in the early Tertiary, along north-south (N-S) and northwest-southeast (NW-SE) oriented normal faults forming a series of asymmetric grabens and half-grabens. Sedimentation patterns and environment of deposition were strongly influenced by local sub-basin topography.

Balanced cross section construction (Dahlstrom, 1969) is a very useful way to extrapolate surface structures to the subsurface. The basic concept of his method is that the geometric features of any constructed section must be retrodeformable to the restored section. Bed lengths and areas must be equal both in deformed cross-section and undeformed restored section. Balanced cross section construction has been very successful in understanding complex structures.

Cross-section balancing techniques will be used in this study to validate existing seismic interpretation and to improve the understanding of the structural development and regional tectonics of the area. The study will utilize reprocessed regional seismic data and available well data. Its results will also have implication for the Tertiary tectonics of the Gulf of Thailand and surrounding regions.

1.2 Objectives and Scope

1.2.1 To analyze the structural development using cross-section balancing method of seismic profiles.

1.2.2 To better understand structural control on sedimentation.

Scope: This study uses geologic information from wells and seismic data in the study area. Regional structural restorations of cross-sections across the area need to be carried out using a cross-section balancing technique.

Methodology: This independent study follows the workflow below.

- Literature review on regional geology and tectonic setting.
- Compilation and correlation of well and seismic data.
- Seismic interpretation and cross-section balancing.
- Basin development model construction.
- Report writing.

1.3 Location and Dataset of study area

The study area is located in the north Malay basin, Gulf of Thailand (Fig. 1.1). The interested structure of interest is called Graben Trend, which is located in the Arthit project (Fig. 1.2). The area approximately 450 km^2 with is 3D seismic data coverage.

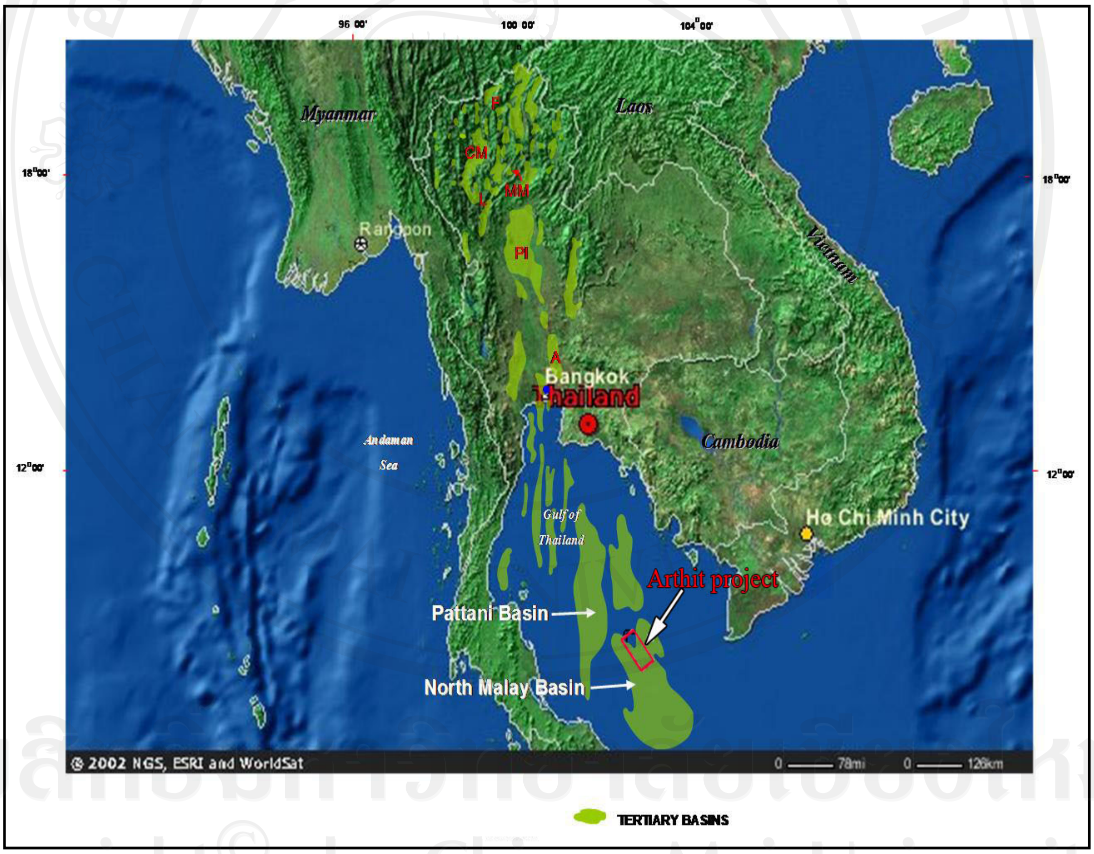

Figure 1.1 Map showing Tertiary basins in the Gulf of Thailand and the location of the Arthit project (Modified from PTTEP Technical forum, 2005)

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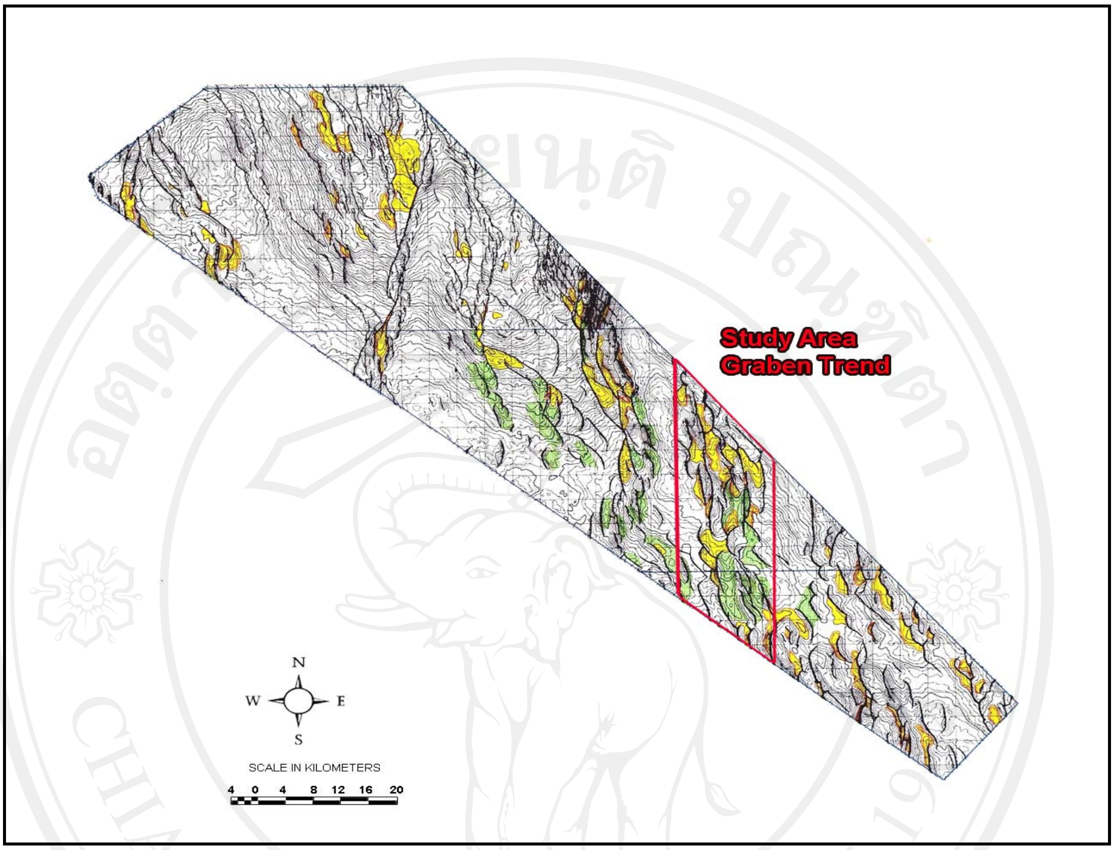

Figure 1.2 Map showing the location of study area. (Modified from PTTEP, 2007)

The 3D seismic data used in this study was provided by the PTT Exploration and Production Public Company Limited (PTTEP), Chevron Thailand and MOECO. The seismic interpretation and mapping were generated on the Sun Solaris$^{\underline{TM}}$ workstation using Schlumberger Charisma® program.

1.4 Literature review

-*General geology*

The Gulf of Thailand is located southeast of Thailand and is surrounded by Cambodia and Vietnam to the east and Malaysia to the south. There are several structurally complex basins in the Gulf of Thailand. These are made up of asymmetrical grabens filled with non-marine to marginal marine Tertiary sediments, the oldest of which is probably Eocene in age. The rift basins developed as a result of oblique-slip extensional tectonics (Morley, 2004) with the interaction between the extension direction and the pre-existing rock fabrics (Morley, 2001; Kornsawan and Morley, 2002)

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Hutchison (1973) and Hamilton (1979) considered the creation of the Malay and Penyu basins along with that of the Gulf of Thailand (Pattani) Basin (to the north-northwest), the West Natuna Basin (to the east of the Penyu Basin and southeast of the Malay basin), and other basins in the South China Sea, as being the result of the interaction of stresses acting on two opposite sides of the Sunda microplate. They thought that the stresses were caused by (1) the collision of the Indian and Eurasian plates, and (2) the opening of the South China Sea through seafloor spreading. The net effect of these stresses on the Sunda plate, which was being "sandwiched" by the northward motion of the Indian plate on the west and south, and on the east by the southward motion of the South China Sea seafloor and the Borneo landmass, was that the plate was slightly rotated clockwise, elevated, arched, and domed. Because arching created tensile stresses within the crustal landmass, it eventually fractured to form grabens and half-grabens.

The Malay basin is an intracratonic basin or interior fracture trough (Kingston *et al*., 1983) within a relatively stable complex of the Sunda Shelf (Khalid Ngah, 2000). It developed through (1) an extensional phase which represents the period of basin opening and rapid sediment accumulation, commencing from the Late Cretaceous - Late Eocene to Late Miocene (2) a compressional phase in the Late Miocene - Pliocene, which formed most of the domal and anticlinal features, many of which trapped hydrocarbons, and (3) an extensional phase of basin rejuvenation, with extensive marine incursion and sedimentation during the Pliocene-Recent. During the Late Miocene - Pliocene, the southeastern part of the basin experienced adjustment of fault blocks and subsequent faulting, which resulted in exposure of reservoirs and their digenetic modification.

Parke *et al.* (1971) and Pupilli (1973) focused on the descriptions and tectonics of the South China Sea and indicated the importance of both extension and compression in the development of the Malay basins. They proposed that the basins were formed during the Late Cretaceous-Early Eocene.

The general stratigraphy comprises four formations overlying the Pre-Tertiary basement. The formations have been numbered 0 to 3 successively upward, and have been related to the tectonic history as follows (Intrawijitr, 1998) (Fig.1.3).

Formation 0 was deposited during rifting

Formation 1 and Formation 2 were deposited during the sag phase.

Formation 3 was deposited during a regional subsidence phase.

There are several geoscientists who applied cross-section balancing techniques in structural analyses of various regions.

House (2004) used cross-section balancing working in thrust belts. The interpreter can produce a 3D structurally balanced interpretation based on a grid of 2D seismic profiles. This in turn produced less error in drilling prognosis and tying wells in structurally complex areas and it also improved the ultimate volume calculations of trapped hydrocarbons.

Hatcher (1995) devised cross-section balancing to improve the understanding of thrusts and other faults. Seismic reflection data are essential when constructing cross-sections through brittle deformed thrust faulted terranes. Balancing may be accomplished by measuring the lengths of deformed layers and restoring the section to an undeformed condition. If the section can be retrodeformed and reconstructed, the interpretation may be correct. Balancing is also possible by taking the areas of units in the section and restoring them to an undeformed condition.

Whu Shigu, Ni Xianglong and Guo Junhua (2007) balanced cross-section for restoration of tectonic evolution in the southwest Okinawa Trough on the concept of the multi-channel seismic data and the other data, using the Midland Valley 2D Move® software. The tectonic restoration and seismic interpretation show that since the Pleistocene the depocenters have migrated to the east; several large faults controlled the development of minor faults and strata; the Okinawa Trough has experienced two spreading event since the Pliocene, the early was fault depression in the Early-Middle Pleistocene, the late was back-arc spreading from Late Pleistocene to Holocene, Present day, it is in the initial stage of oceanic crust spreading.

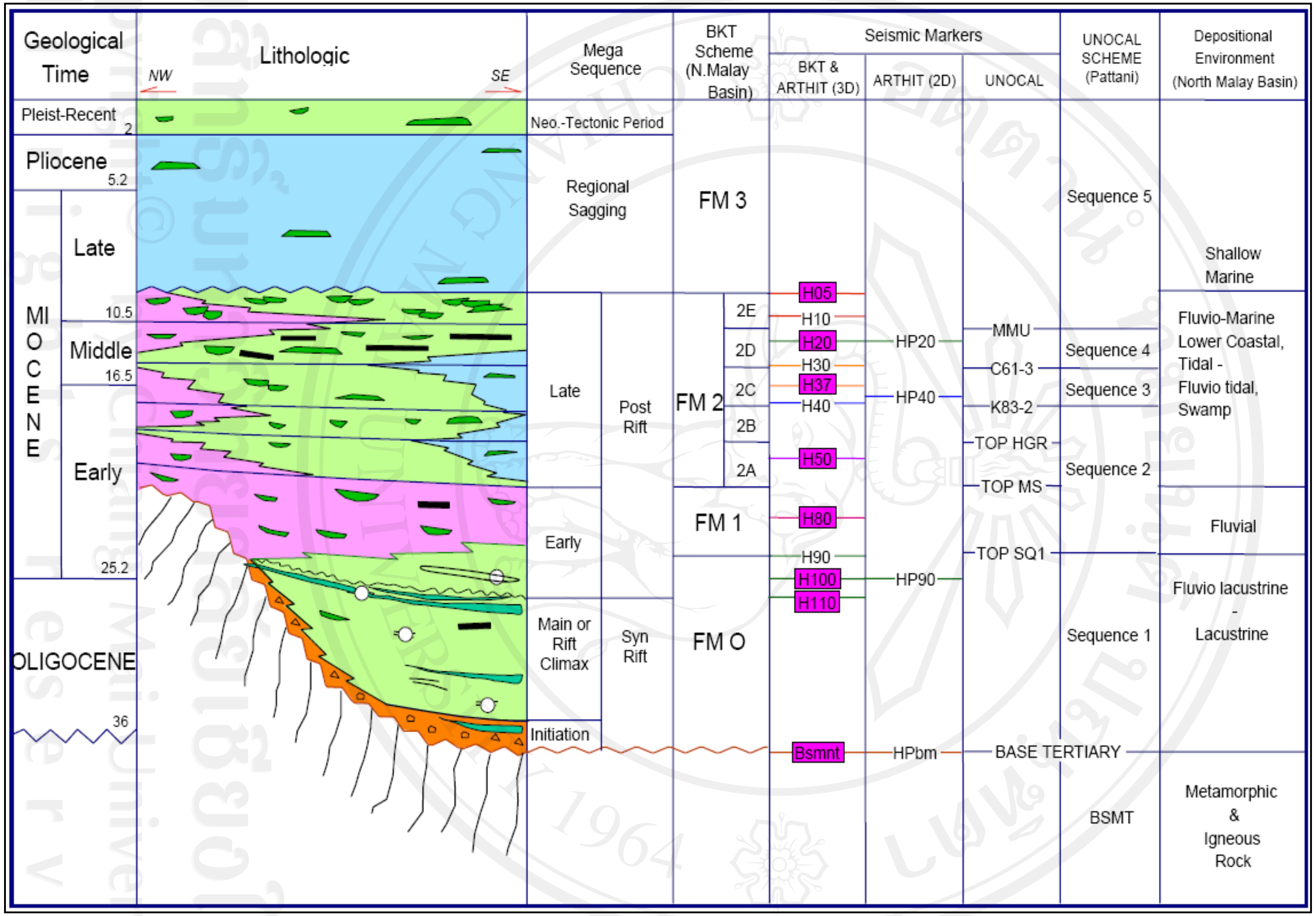

Figure 1.3 General stratigraphy in the North Malay Basin (Intrawijitr,1998)