Chapter 1

INTRODUCTION

The volumes of hydrocarbons that exist in subsurface reservoirs and the recoverable amount from these volumes are very important in the oil industry. During the exploration period, the recoverable volume of hydrocarbons is needed to judge if a new discovery prospect may be economically produced. During the development and production periods, knowing the recoverable volume of hydrocarbons helps to make a reasonable production plan. Even in the near-ending production period, the tertiary production period, the volume of hydrocarbons remaining in reservoirs is still needed to design an enhance-oil-recovery program.

At the beginning of a field life, even during the production phase, geological and petrophysical data, such as the extent of reservoirs, the variation of reservoir thickness, the distribution of porosity, and hydrocarbon saturation, and hydrocarbon properties in the reservoirs, are not adequately known. These factors contribute to the uncertainties in calculating the hydrocarbon reserves. Monte Carlo simulation is a method that combines all parameters with their own uncertainties and gives a distribution forecast with different levels of probability. For estimating petroleum reserves, a Monte Carlo simulation is performed based on the volumetric calculation.

In this study, a Monte Carlo simulation was applied to estimate the reserves of the lower production zone of the U-Thong field in the Suphan Buri basin, central Thailand. The U-Thong field is a mature oil field with 10 wells and has been produced for 14 years. Nine cases with different conditions were considered. The results were compared with the reserves calculated by the volumetric method and the decline curve analysis to determine the accuracy of the simulation and the limits of the input data.

Geological Conditions of the U-Thong field

The U-Thong field is located in Suphan Buri province, about 80 kilometers northwest of Bangkok, in the Suphan Buri basin, which is an onshore Tertiary sedimentary basin (Figure 1.1). This basin covers an area of 970 square kilometers and is marked by a distinct half-graben morphology. A north-south-trending, east-dipping border fault occurs on the west side of the basin (Figures 1.2 and 1.3). There is no significant topography within the basin. The basin developed during the Early to Middle Triassic on the Shan - Thai continental block and lies between the major strike-slip Mae Ping fault zone to the north and the Three Pagoda faults zone to the south. The west side of the basin lies near the exposed older pre-Tertiary basement rocks of the Shan-Thai continental block. The basin's east side lies under the eastern half of the central plain of Thailand. The deposition in the basin was mainly alluvial, fluvial, and lacustrine sediments (Figures 1.4 and 1.5). This basin is considered to have petroleum potential, having some previously defined prospects and oil fields.

The U-Thong field belongs to the PTTEP1 project, which is solely owned by PTT Exploration and Production Public Company Limited (PTTEP). The PTTEP1 project has of three oil fields, Kamphaengsaen, U-Thong, and Sang Kajai. A 3177 - kilometer 2D seismic survey and 37 - square kilometer of 3D seismic survey were acquired over the project area. The U-Thong field is considered a small oil field and has the estimated ultimate reserves of 2.872 - 3.159 MM STB (PTTEP, 2000). Up to now, there are 10 production wells and one dry hole, UTW-1, in the field. The field production started in October 1991 with two production wells, UT1-3 and UT1-7. The initial rate of the field was about 900 BPD. Later, five additional development wells, UT1-3/D1, UT1-7/D1, UT1-7/D2, UT1-7/D3, and UT1-7/D4, were drilled and put on production at various points in time. After the seven wells were put on production, the production has steadily declined. In the year 2000, three additional development wells, UT1-7/D5, UT1-7/D6, and UT1-7/D7, were drilled. To enhance the oil production and reduce the impact of produced water on the surrounding environment, a water injection program was implemented in early 1999. This water injection slightly increased the oil production rate of the nearby wells. At present, the production of the field is rather low. The announced oil production rate of the U-Thong field in May, 2005 in the website of PTTEP was 343 BPD.

In the U-Thong field, there are two main production zones: Upper Zone consisting of layers KR1-1 to KR2-5, and Lower Zone consisting of layers KR2-6 to KR2-8, which are Middle to Upper Miocene units D2, D3, and D4. The reservoir rocks were interpreted to be fluvio-lacustrine sandstone, fluvial channel sandstone, and conglomeratic sandstone. The Upper Zone was estimated to have a very low recovery factor of approximately five percent. The Lower Zone was estimated to have a higher recovery factor of approximately 30 percent. This difference in recovery factor is because the Upper Zone is believed to have a depletion drive mechanism and the Lower Zone is believed to have a water drive mechanism. Only the Lower Zone was considered in this report. Layers KR2-6 and KR2-7 lie in-between two horizons, S3 (Figure 1.6) and S4 (Figure 1.7), that were mapped by reprocessed seismic data. Horizon S4 is the top of layer KR2-8 (Figures 1.8 and 1.9). In well logs, the oil in the lower layer occurs at a greater depth than the water in the upper layer (Figure 1.10 and Appendix A). This indicates that there is no vertical connection between the three layers. In this study, layer KR2-8 was divided into two sand layers, KR2-8A and KR2-8B, because between them there is a continuous shale bed which can be traced connecting all wells (Figure 1.10). This shale might separate KR2-8 into two layers that have different oil-water contacts. Using well data, the net sand thickness of each layer was mapped (Figures 1.11 to 1.14).

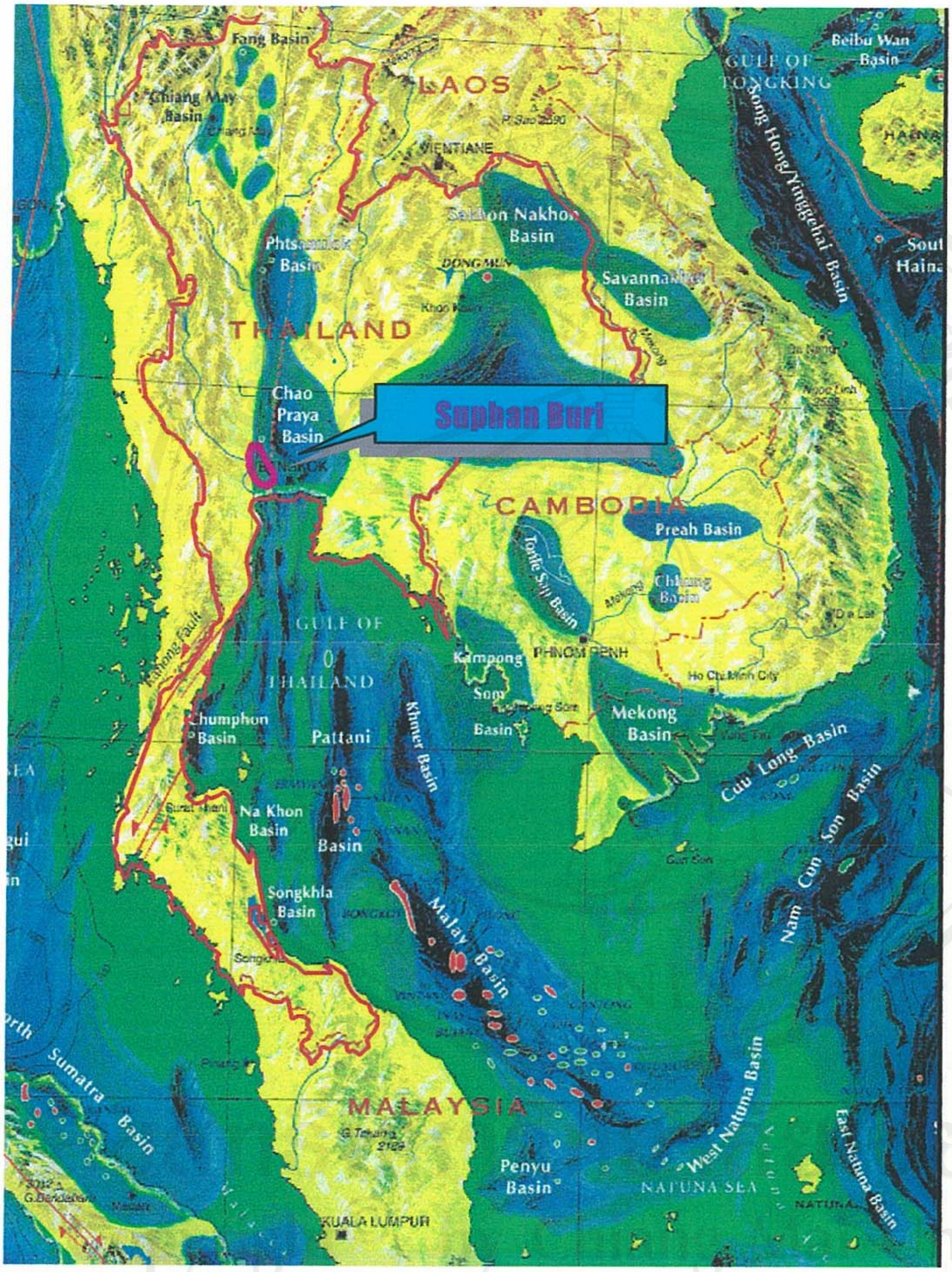

Figure 1.1 Location of the Suphan Buri basin (after PTTEP, 2003)

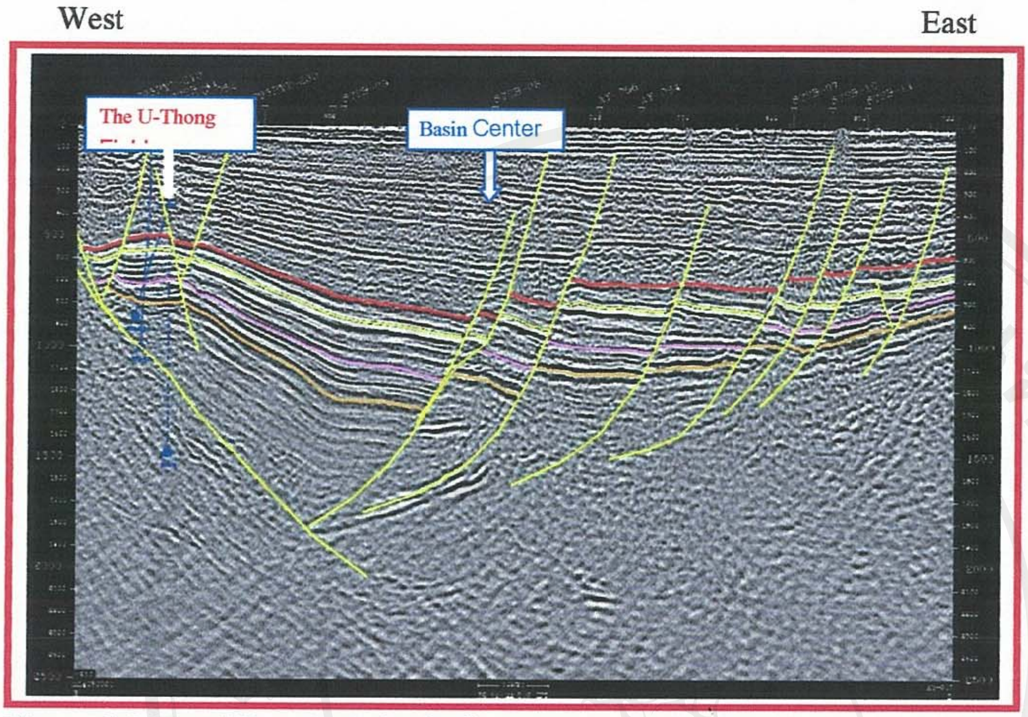

Figure 1.2 East-West 2D seismic line across the Suphan Buri basin (after PTTEP, 2003)

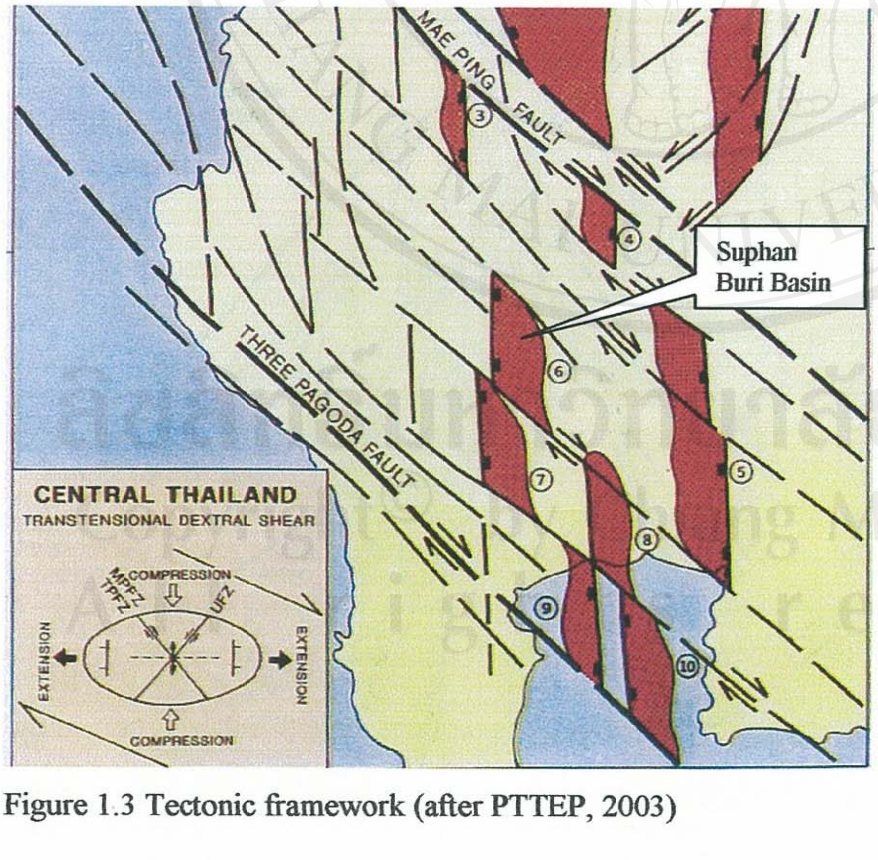

Figure 1.3 Tectonic framework (after PTTEP, 2003)

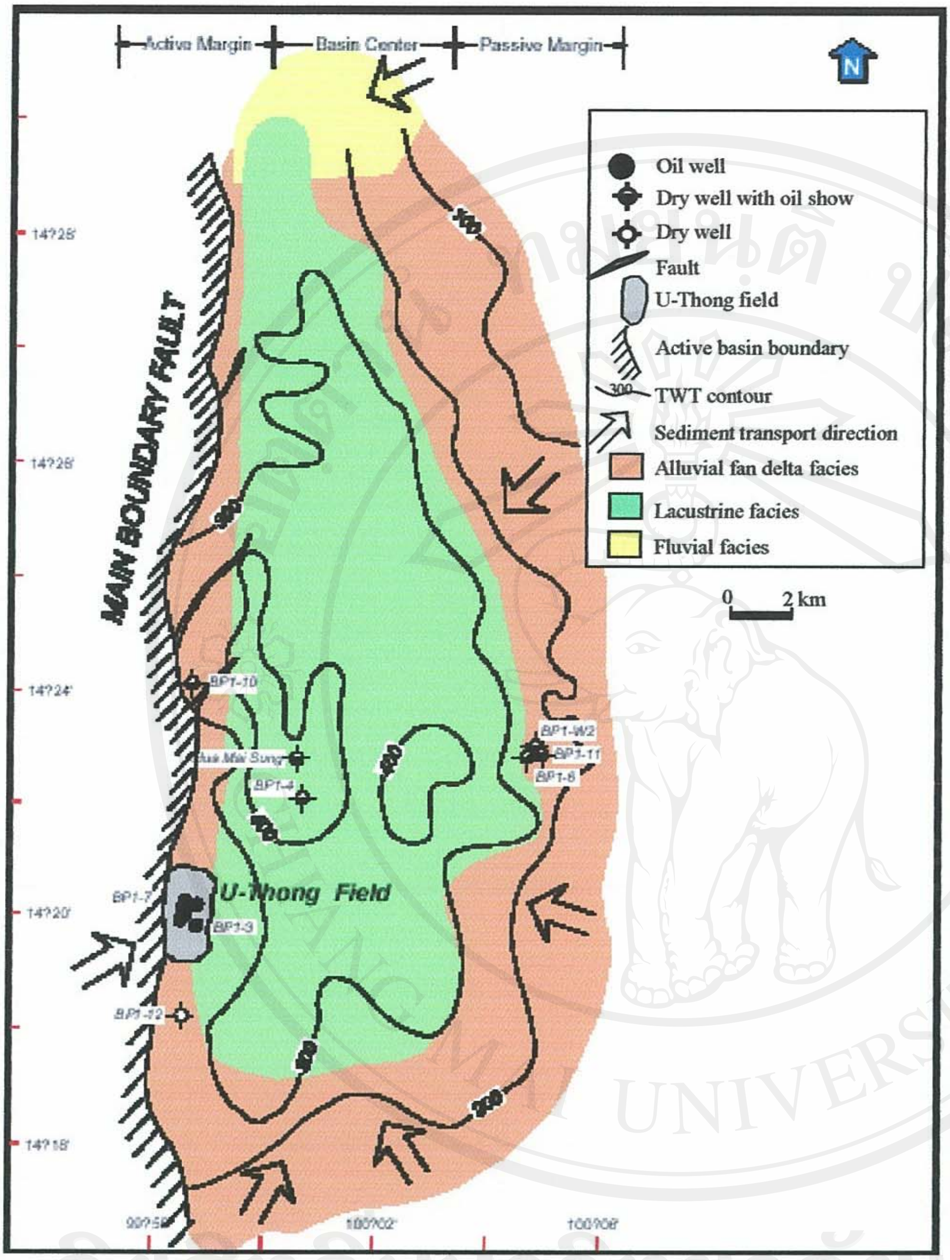

Figure 1.4 Sedimentary facies map of the Suphan Buri basin (after PTTEP, 2003)

Age		Unit		Depth m	Depositional System	Lithology	Petroleum System
Pliocene-Recent		E		500	Alluvial - fluvial	Sand, gravel, siltstone, and mudstone, fluvial origin.	
Miocene	Upper	D	D1	U	Fluvio - lacustrine	Fluvio-lacustrine sandstone and siltstone, interbedded with mudstone.	Reservoirs
			D2	1000			
			D3				
			D4				
			D5				
			D6				
	Middle		D7			Fluvial channel sandstone and conglomeratic sandstone.	Source and reservoirs
	Lower	C	C1	U 1500		Intercalated sandstone, siltstone, and mudstone.	
			C2				Source
			C3			Lacustrine system with fluvial influence.	
			C4				
Oligocene		B			Lacustrine	Mudstone with minor siltstone.	Source
		A		2000	Early basin fill, alluvial - lacustrine	Conglomerate and sandstone, interbedded.	Source and reservoirs
Pre-Tertiary						Basement complex	

Figure 1.5 Stratigraphic sequence of the Suphan Buri basin (after PTTEP, 2003)

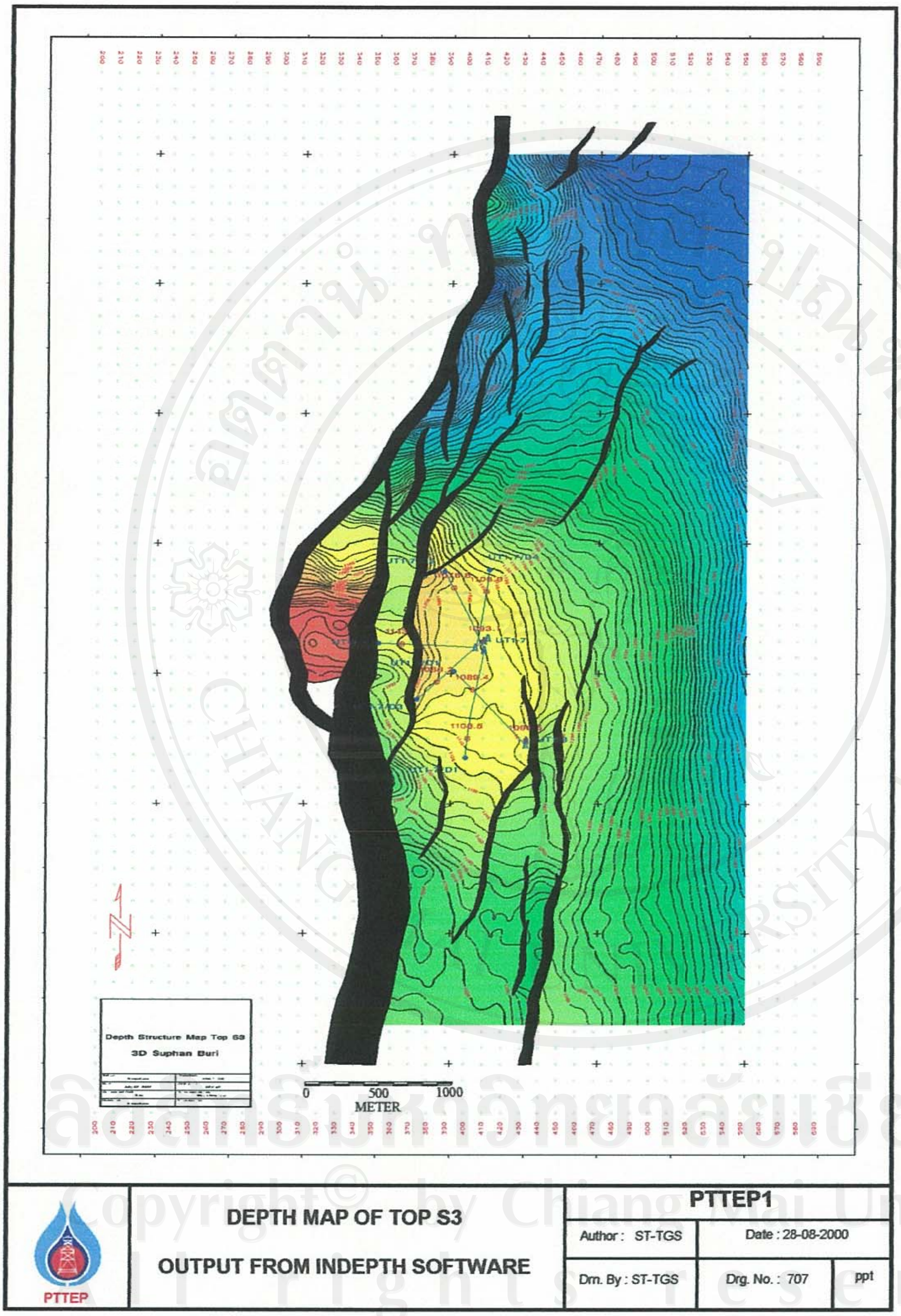

Figure 1.6 Structure map of S3 horizon (after PTTEP, 2000)

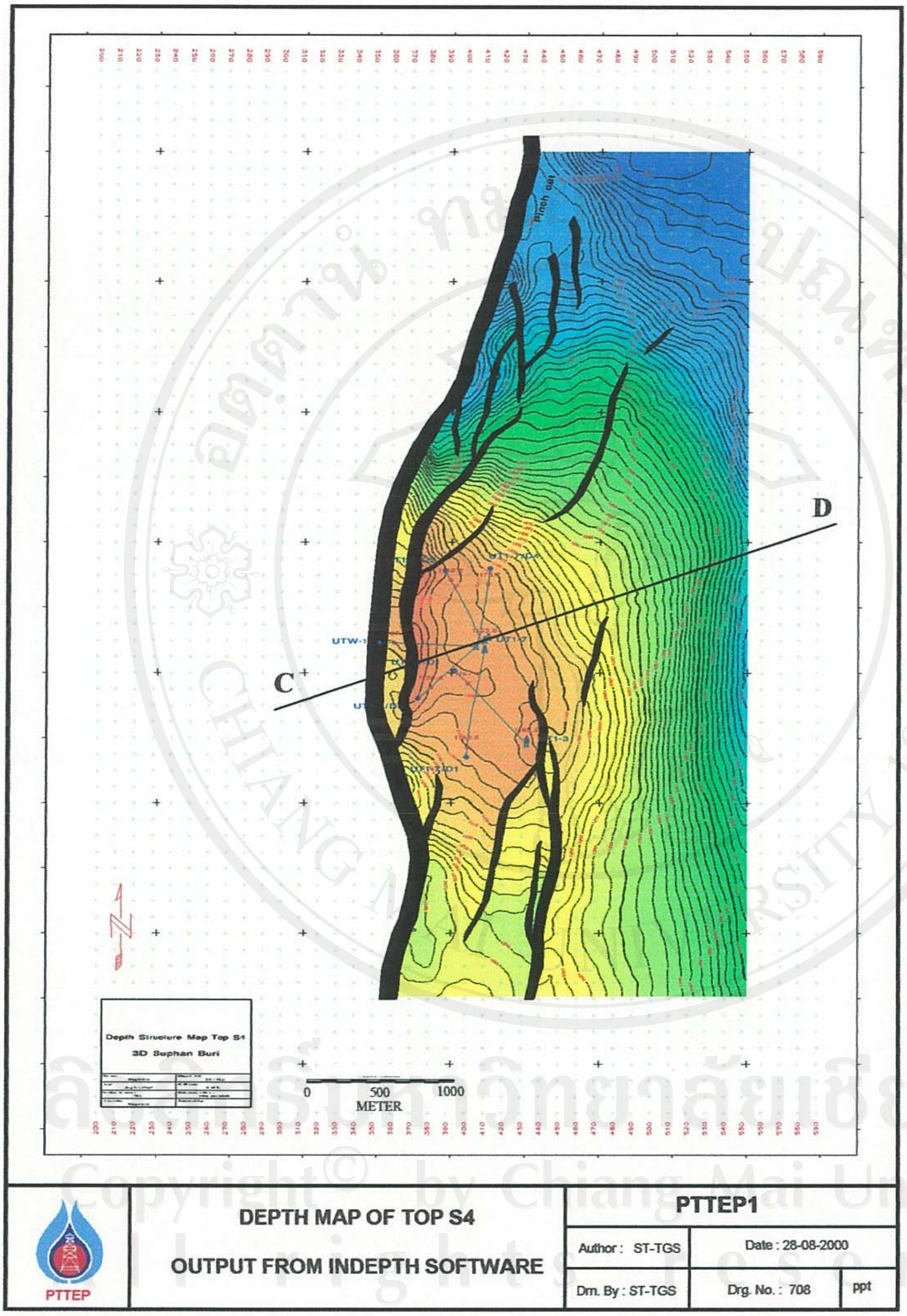

Figure 1.7 Structure map of S4 horizon (after PTTEP, 2000)

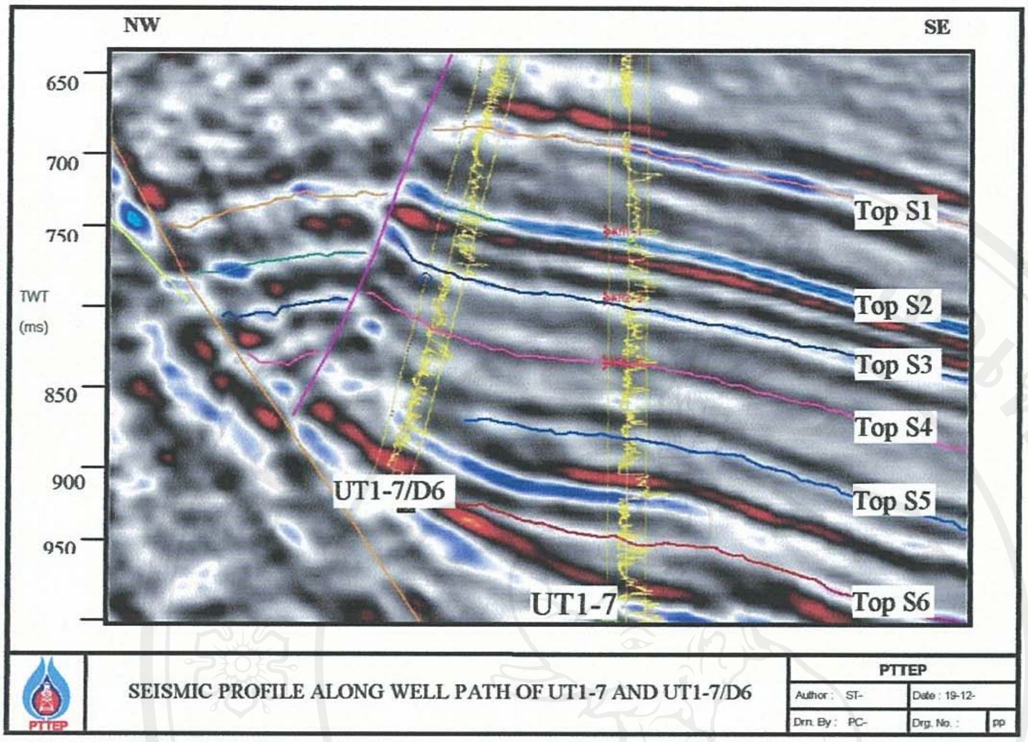

Figure 1.8 3D seismic profile along well path of UT1-7 and UT1-7/D6 (after PTTEP, 2003)

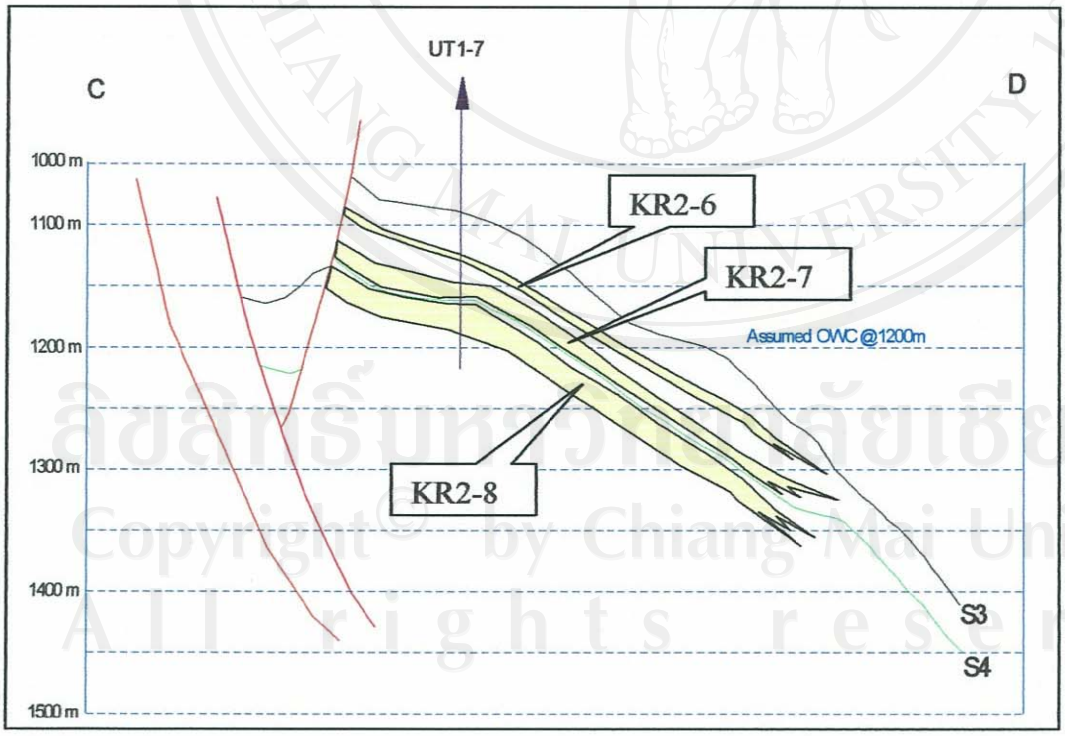

Figure 1.9 Geological cross section of the Lower Zone

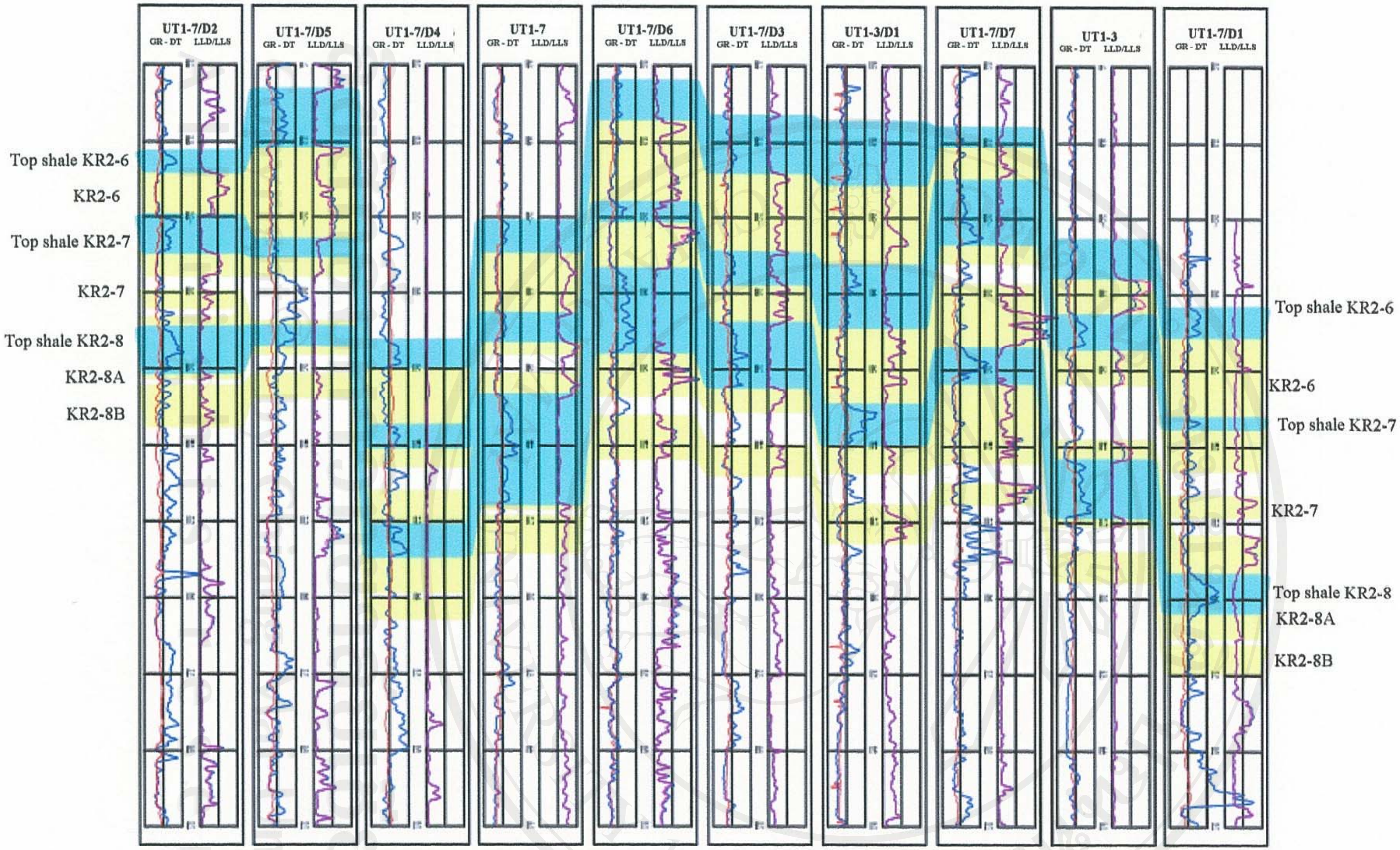

Figure 1.10 Well correlation

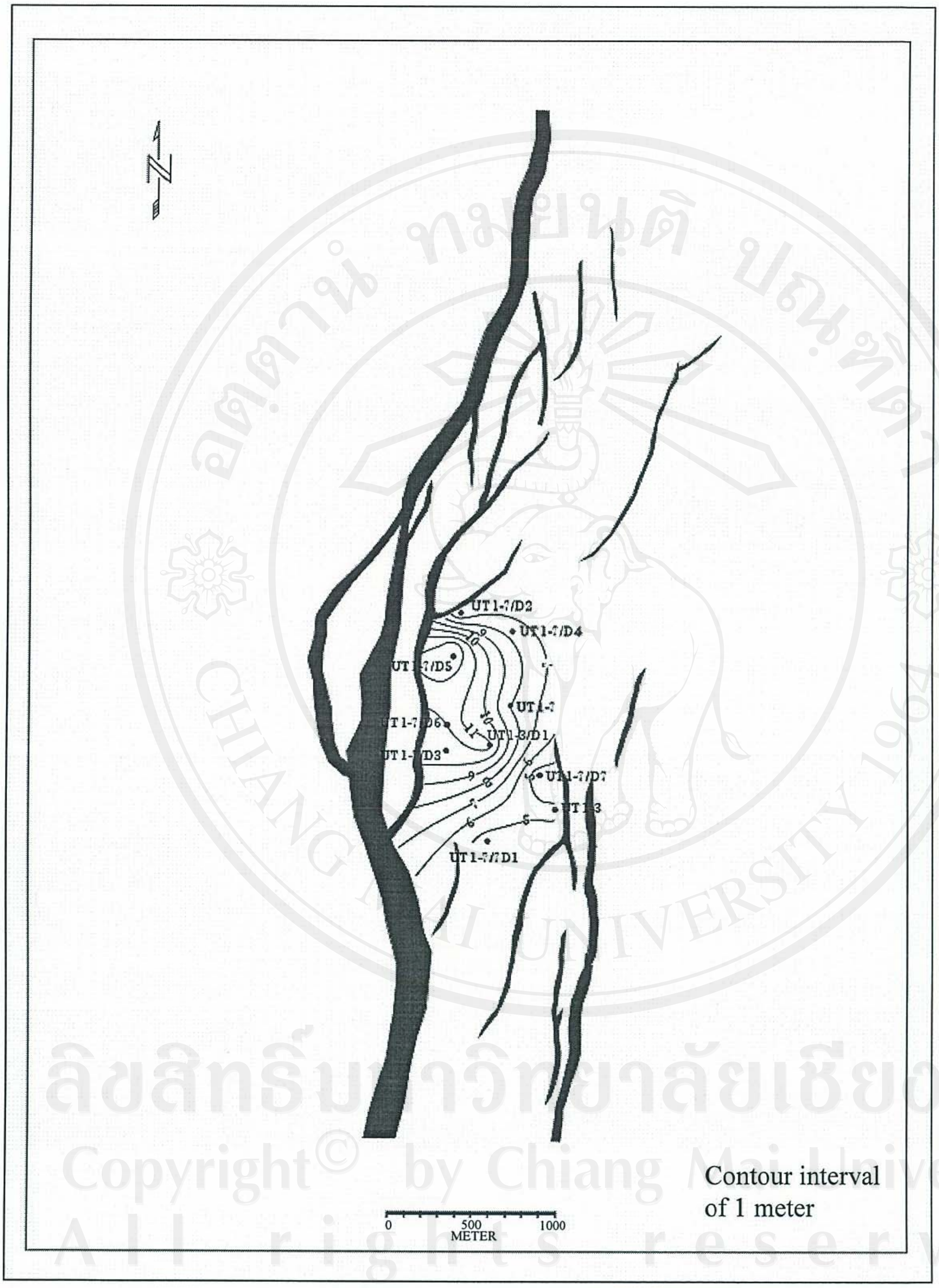

Figure 1.11 Net sand map of KR2-6

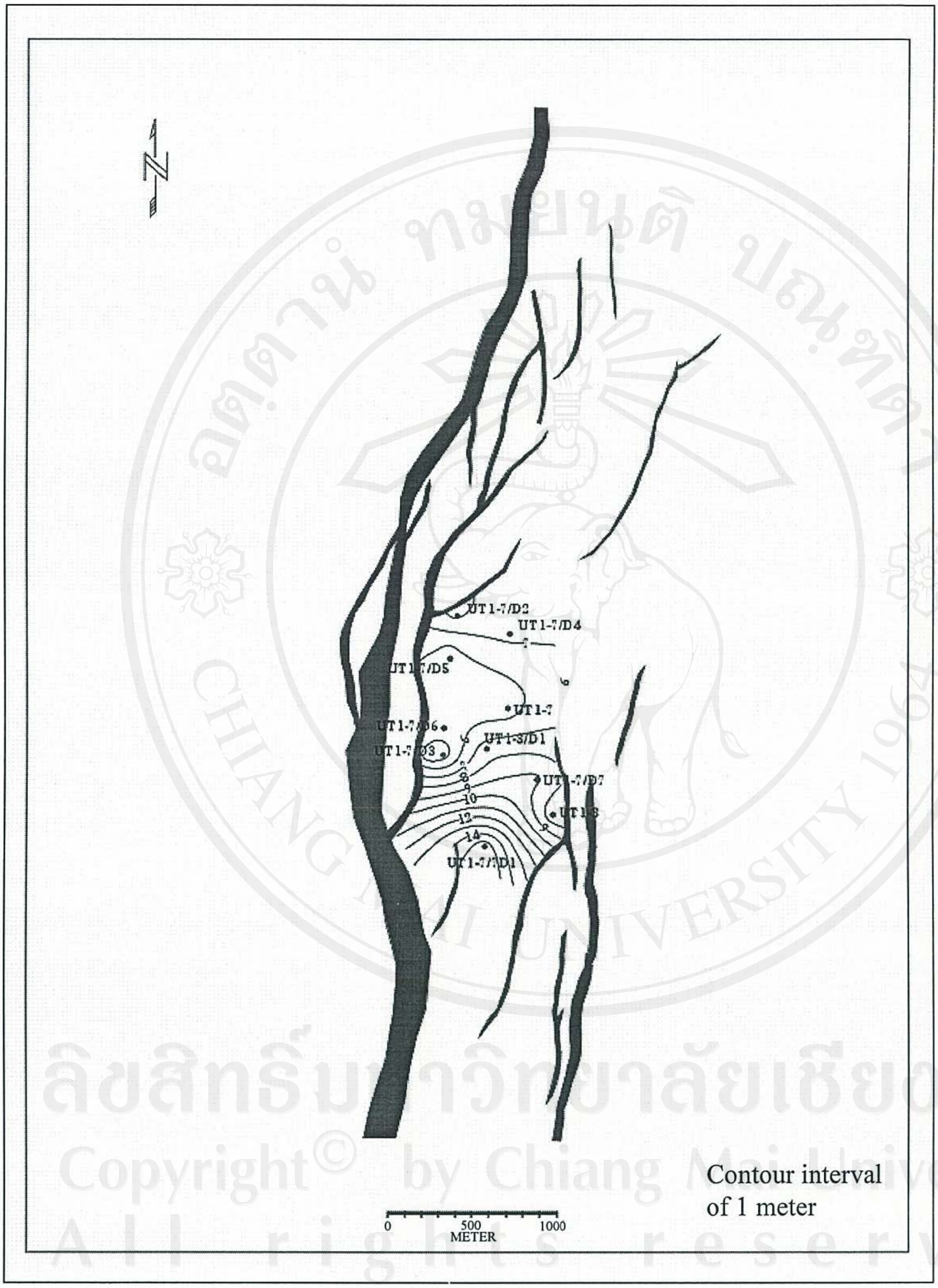

Figure 1.12 Net sand map of KR2-7

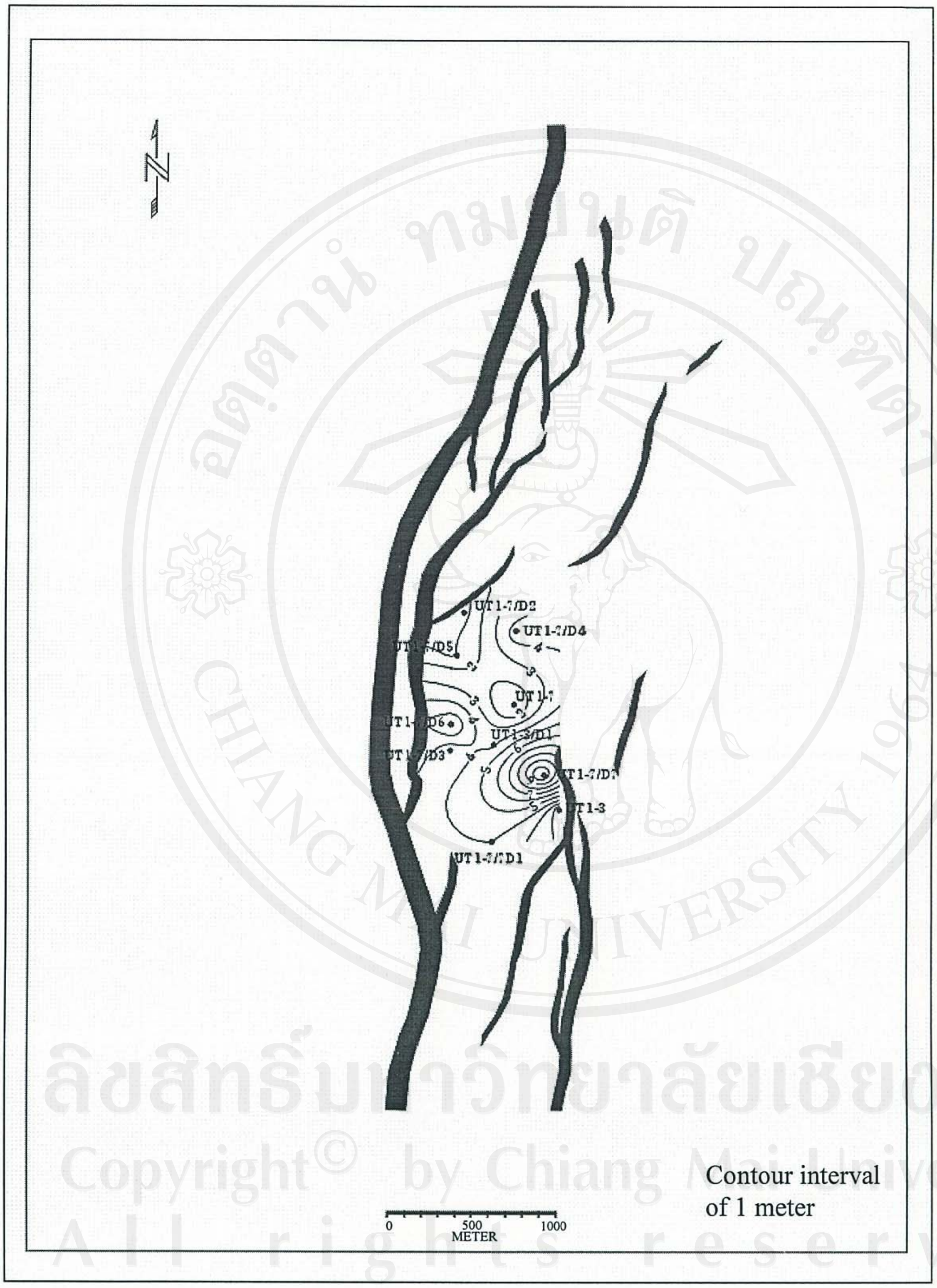

Figure 1.13 Net sand map of KR2-8A

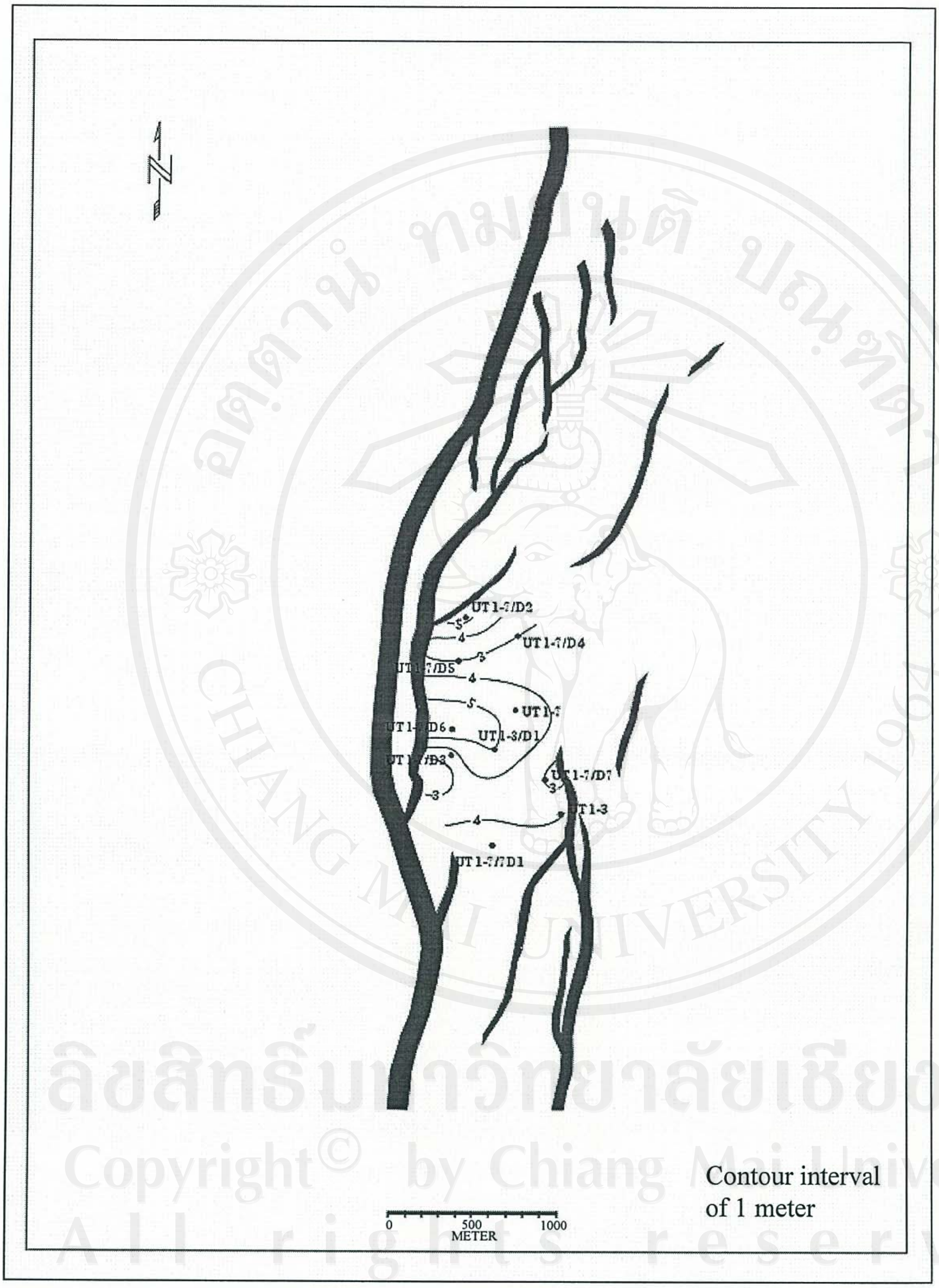

Figure 1.14 Net sand map of KR2-8B