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Contributed Paper

Seismic Stratigraphy of the Fang Basin, Chiang Mai, Thailand

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ABSTRACT

The Fang Basin is located about 150 km northwest of Chiang Mai. Based on characteristics of reflection seismic data, the Cenozoic sediment in the centre of the basin can be subdivided into 7 units (Sequences 1-7), which have been interpreted as being deposited in fluvial and lacustrine environments. These basin fills are underlain by Pre-Tertiary basement comprising weathered andesite and Permian limestone. Sequence 1 represents the initial deposition during the opening of the basin. The top of the sequence is marked by bituminous shale and lignite in the eastern part of the basin. These strata have been regarded as good source rocks for the oil fields in the area. Sequence 2 is a west-directed prograding succession of sandstone interbedded with shale. Sequence 3 has been interpreted to represent a transition in depositional regime from sand-dominated fluvial to mud-dominated lacustrine environments. The upper boundary of the sequence is marked by a coal layer indicating a period of low energy and wet conditions. Sequence 4 consists of a prograding succession of sandstone and shale, representing a change in depositional environment to one of higher energy than that of Sequence 3. Sequence 5 comprises sand-dominated strata at the basin margins that grade into mud-dominated strata in the basin centre. Most reservoirs in the Fang oil fields are located within Sequence 5. Sequence 6 consists largely of shale with minor sand interbeds. Sequence 6 is unconformably overlain by Sequence 7, composed of interbedded sandstone and shale. Based on the architecture of the sedimentary layers and distribution of sediment types, it has been interpreted that the basin fills were supplied from the western and eastern margins of the basin.

Keywords: seismic stratigraphy, Fang basin, Tertiary, depositional environment, lacustrine, fluvial.

1. INTRODUCTION

The Fang oil field is a small oil field in a Tertiary basin about 150 km northwest of Chiang Mai and it is the first to have been developed in Thailand. The Fang basin is a NNE-SSW trending intracratonic basin [1]. It initially opened in the Early Tertiary and evolved in the Middle Tertiary in a trans-tensional regime [2]. In the Pliocene and Pleistocene, it was affected by compression under a transtensional/transpressional left-lateral tectonic setting. The Tertiary depositional environment was fluvial and lacustrine that changed into fluvial and alluvial conditions in the Quaternary [3-6]. Structurally, the Fang basin is a half-graben that has a steep faulted western flank and a gently dipping eastern flank [2].

Previously, seismic data were interpreted with intention to delineate geological structures. There were stratigraphic studies based on only well data. The concepts of seismic stratigraphy have not been applied to their efficient use in the previous seismic interpretation. Therefore, existing geological information at the Fang Oil Field were not used to accurately locate reservoir rocks, especially in the present-day where more attention has been focused on small structures with petroleum potential.

The aims of this research are to understand the seismic stratigraphy and depositional environment based on both seismic data and well data.

2. MATERIAL AND METHODS

A 3D reflection seismic survey was carried out in the central part of the Fang basin between the Latitudes 19° 56′ to 19° 46′ N and Longitudes 99° 06′ to 99° 16′ E (Figure 1). Existing data from 120 wells have been used in this study. Depths of pay zones in all oil fields have been determined in wells and converted to seismic two-way travel time using the Vertical Seismic Profile curves. These depths were used to correlate well data to seismic data. The seismic data were interpreted using the software Schlumberger Geoquest Geoframe®. The interpretation resulted in seismic time-structure maps and attribute maps of the reservoir horizons and related seismic units. All data were then compiled and used for the interpretation of depositional environments.

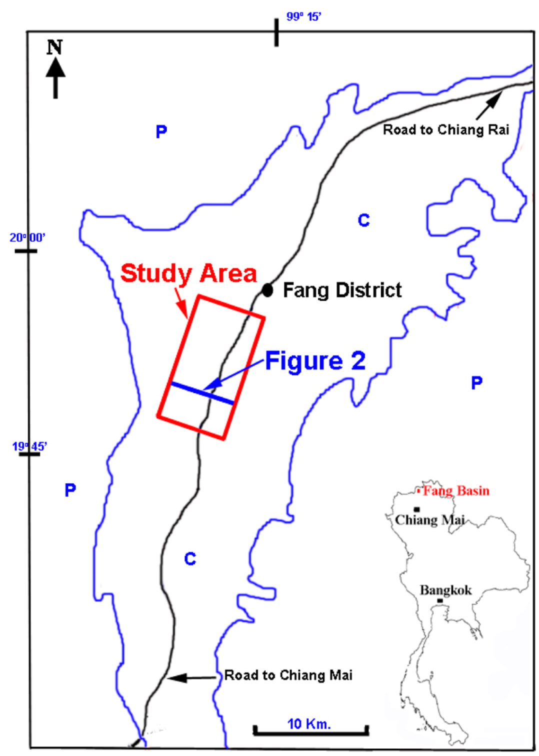

Figure 1. Map showing location of the study area. C = Cenozoic rocks; P = Pre-Cenozoic rocks.

3. RESULTS AND DISCUSSION

3.1 Sequence Interpretation

Based on the characteristics of seismic reflections, seven seismic sequences have been identified and described successively upward as follows (Figure 2).

The Pre-Tertiary basement is characterized by chaotic and discontinuous reflections with moderate to low amplitude and low continuity. It is tilted to the west and the upper part of the unit has irregular reflections that are cut by east-dipping faults.

Sequence 1 consists of weak seismic reflections with low to moderate amplitude and poor continuity. The amplitude the upper boundary increases eastward. The unit is the thickest in the northeastern part of the area.

Sequence 2 the seismic reflections have moderate to high amplitude and poor to moderate continuity. The unit is the thickest in the northeastern part of the area. In the east, the upper boundary features toplap and erosional truncation. The lower boundary is characterized by westward downlap of seismic reflections. Internally, reflection configuration can be described as sigmoid to oblique clinoforms. The unit pinches out eastward onto the lower boundary and thins toward the west.

Sequence 3 consists of chaotic seismic reflections with poor continuity. It pinches out eastward and thickens toward the western basin-bounding fault. Internal reflections are sub-parallel with moderate to low amplitude and onlap onto the lower boundary. The upper boundary is a concordant reflection with moderate to strong amplitude.

Sequence 4 has similar seismic characteris

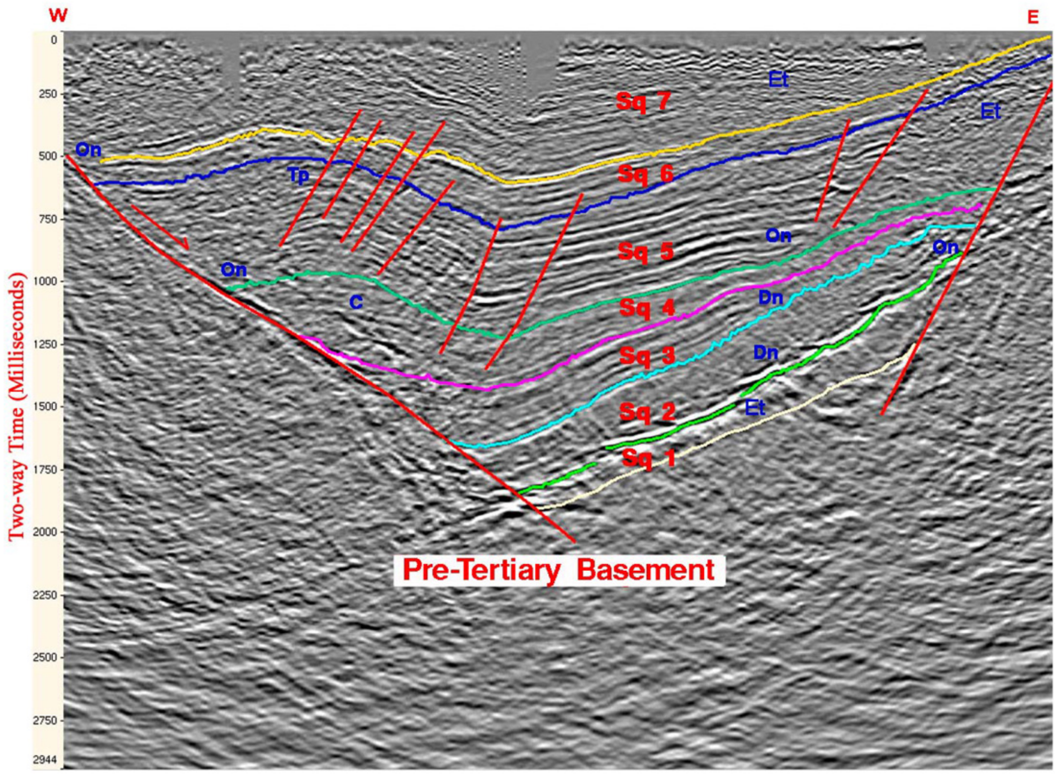

Figure 2. Interpretation of a seismic profile across the study area with 8 seismic units Basement and Sq1 to Sq7. Location of profile is shown in Figure 1. On = onlap; Dn = downlap; Tp = Toplap; Et = erosional truncation; C = clinoform.

tics to those of Sequences 2 and 3. It is a prograding unit that thins eastward and thickens toward the western basin-bounding fault. The seismic reflections within the unit have high amplitude.

Sequence 5 can be separated into five subsequences: 5I, 5H, 5G, 5F and 5E, successively upward. Most reservoirs of the Fang oil fields are located within Sequence 5. The seismic reflections in the unit are sub-parallel and have moderate to high amplitude with moderate to good continuity. The reflections onlap onto the lower boundary at the western and eastern margins of the basin. The upper boundary is characterized by erosional truncation in the east and toplap in the west. Strong reflections occur near the basin margins and become less prominent in the basin centre.

Sequence 6 consists of seismic reflections inside the unit with low to medium amplitude and moderate continuity. The reflections onlap onto the lower boundary at both basin margins. The upper boundary is characterized by erosional truncation over most of the area.

Sequence 7 consists of seismic reflections with low amplitude and moderate to poor continuity. The reflections are better resolved in the basin centre. At the basin margin, they appear to onlap onto the lower boundary. In the western half of the basin, erosional truncation characterizes the upper part of the unit.

3.2 Depositional Environments

Depositional environments of the basin fills were interpreted from analysis of seismic reflections in combination with well data. This information is considered crucial in predicting the possibility and suitability of a prospected area. Depositional environments for the seven seismic units are discussed as follows.

In general all of the seismic units represent sediment that was deposited in a continental environment including purely fluvial and lacustrine conditions as well as the transition between the two regimes.

Based on well information, the Pre-Tertiary basement consists of weathered andesite and Permian limestone [6].

The sandstone in Sequence 1 has been described as poorly sorted, angular and rich in Feldspar and rock fragments. This information and its seismic characteristics of low to moderate amplitude and poor continuity indicate that the unit was probably deposited in a fluvial environment with the sediment sources at the basin margins. The upper boundary has very strong amplitude and corresponds to bituminous shale and lignite, which are regarded as good source rocks in the eastern part of the Fang basin [7].

Well information reveals that Sequence 2 consists of a series of sandstone interbedded with shale. The sandstone is grayish and well-sorted with sub-angular to sub-rounded grains. The alternation of sandstone and shale provides seismic reflections with moderate to high amplitudes and poor to moderate continuity. Clinoform seismic configuration indicates a westward-directed prograding unit [7-9].

The sub-parallel to chaotic reflections with poor continuity of Sequence 3 can be interpreted to represent deposition in a low-energy environment or a lake where mud dominated [10]. The strong reflection at the upper unit boundary corresponds to coal that indicates a possible swampy environment, especially along the lake margins [7].

Clinoform configuration in seismic profiles of Sequence 4 indicates a westward-directed prograding unit [7, 11]. Strong reflections within the unit correspond to alternation of sandstone and shale. Data from wells show that the sandstone is moderately sorted with angular to sub-rounded grains.

Sequence 5 comprises sandstone interbedded with shale. The sandstone forms reservoirs in the western part and the eastern part of the Fang basin. The internal reflections are sub-parallel and onlap onto both the western and eastern basin margins. The strong seismic amplitudes at the basin margins that decrease toward the basin centre can be interpreted as a transition from alternating sandstone and shale in the shallower part to dominantly shale in the deeper part of the basin. This information suggests that the sediment was supplied by sources on the basin flanks [12, 13].

Sequence 6 consists of dominantly shale interbedded by minor sandstone. The upper boundary of the unit shows erosional truncation that can be interpreted as an unconformity corresponding to a seismic reflection with have moderate to low amplitude and moderate to low continuity [14].

Sequence 7 is the youngest sequence. Seismic reflections in this sequence have low amplitude and moderate to poor continuity that probably correspond to alternating sandstone and shale layers. At the basin margins, they appear to onlap onto the lower boundary and the reflections are better resolved in the basin centre. Therefore, the sediment has been interpreted as being supplied from the basin margins [7-9]. In the western half of the basin, erosional truncation characterizes the upper part of the unit. This erosion was probably a result of local or regional uplift of the basin [14].

4. Conclusions

Seven seismic units have been identified based on the analysis of seismic characteristics integrated with well data. The depositional environments of the Tertiary sediment in the Fang basin have been interpreted as fluvial to lacustrine.

This study has implication for the study of Tertiary stratigraphy of Thailand and surrounding regions as it can be used as an analogue in comparable research in other Tertiary basins. The results can be applied to the prediction of the geometry and distribution of petroleum reservoirs and ultimately to the estimation of reservoir potential of hydrocarbon prospects.

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