The Tectonic Evolution and Hydrocarbon Habits of the Cenozoic Rifting and Foreland Basins, Western Taiwan

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ABSTRACT

Five major types of sedimentary basins including rifting basin, extensional basin, relic back arc basin, foreland basin and forearc basin on the offshore and onshore Taiwan are recognized in terms of basin architecture, lithofacies of the basin-filled sediments, regional geology, surface and subsurface geological data. Among these basins, the rifting and foreland basins located on the western Taiwan are the most important to the hydrocarbons.

Basin distribution associated with regional tectonic setting suggests that the tectonic evolutions of the western Taiwan sedimentary basins on the East Chinese Continental Margin are characterized by 1) progressive younging in age from west to east, 2) progressive complication of basin-type through age and 3) drastic change from extensional to compressional tectonic force through age. The basin development includes the following steps: 1) the formation of rifting half-graben basin initiated by asymmetric, extensional faulting on the inner continental shelf in Paleocene and Eocene; 2) the formation of extensional and relic backarc basins on the shelf-break in Oligocene; and finally; 3) the formation of foreland together with forearc basins on the eastern edge of the continental margin in Early Pliocene, which were resulted from the interaction of the Philippine Sea Plate and the Chinese Continental Margin.

The Early Tertiary rifting basins, including Tungyintao, Nanjihtao and Penghu basins located in the western part of the Chinese Continental Margin, are typical half-graben filled with syn-rift Paleocene and Eocene sequences derived principally from Mainland China. These syn-rift sequences are separated from the overlying post-rift Neogene sequences of sheet-like layers by the major sequence boundary (H 4), characterized by an obvious angular unconformity with a rather large in scale of stratigraphic gap dated from Middle Eocene to Late Oligocene. In terms of passive margin tectonostratigraphy, the Paleogene and Neogene deposits can be deemed as the rift and drift sequences respectively. The rifting of the southeast Chinese Continental Margin is estimated consequently to be initiated as early as Early Paleocene in response to a rifting event that led to the opening of South China Sea, the incipient spreading of it being therefore dated from Late Oligocene.

The rifting basins are predominated by NE-SW trending normal faults, which are consistent with regional structural trend of the major bounding faults. No

major change in stress directions as well as in tectonic mechanism was observed during Early Paleocene to Early Oligocene, suggesting that no significant destructive effect on the migration and accumulation of hydrocarbons trapped either in the prospects of faulted anticline and rollover associated with normal faults or in the stratigraphic prospects of deltaic and alluvial fans. The characteristics of the basin architecture, lithofacies, burial and thermal history suggest that the Paleocene and Eocene sequences of these rifting basins are favorable potential targets for future hydrocarbon exploration.

The presence of volcanic activity as identified in the Paleocene and Eocene sequences further leads it to be classified in the category of a hot basin, which would be provided with a favorable thermal condition for hydrocarbon generation.

The foreland basin, which is expanded the greatly parts of onland Taiwan and is bordered by a westward moving fold-and-thrust belt to its east, has been developing on a previously uplifted margin of an extensional basin, of which the width and extension increase toward the east. The foreland basin was formed owing to the continuous collision of the Philippine Sea Plate and Eurasian Plate since Late Miocene. The Taiwan foreland basin is composed of proximal and distal belts. The proximal belt located on the east is characterized by containing a series of low angle implicated fold-thrust structures. The rocks are mostly composed of Early Neocene clastic sediments. The distal belt, which is located on the western coastal plain and might extend to the eastern part of the Taiwan Strait, is greatly composed of Later Neocene clastic sequences. This belt is characterized by containing a number of rather higher angle thrust-fold structures. The exploration well data shows that the structural style in the inner part of the foothills belt is primarily characterized by fold-and-thrust or simple anticline-syncline feature on the surface. The surface and subsurface structural settings in the inner part of the foothills belt extend into the outer part of the belt and form complex structures in the fold-and-thrust belt, where they appear as transverse structures and segment the surface structural settings in the fold-and –thrust belt, or they are cut and buried in the footwall of low angle thrusts, or they might affect the development and three-dimensional geometry of solitary low angle thrust in the subsurface.

In the distal part of the foreland basin, rapid subsidence following the uplifting indicates the onset of episodic each phase of development of the foreland basin. The characteristics of stratigraphy architecture in the foreland basin are: 1) westward on lapping of the sequences in the distal part of the basin, associated with initial rapid subsidence stepwise younging toward the craton, 2) unconformities that punctuate the on lapping of the sequences and also are younging to the west, 3) several later phases of rapid subsidence recognized across the entire area and immediately succeeding the unconformities to the

west, and 4) submarine truncation followed by deposition of coarsening-upward sequences during each phase of the rapid subsidence. The stratigraphic features cannot be explained by a simple eustatic sea-level fluctuation but rather should be related to eastward migration of fore- bulge during episodic westward movement of the fold-and-thrust belt and later progradation of deposition toward the craton.

The hydrocarbons in the foreland basin are play important role in western Taiwan. A number of hydrocarbons are found from the faulted anticline traps formed by the thrusting along the lower angle decollement. Concerning with the facts of the thermal maturation and tectonic evolution of the foreland basin, some hydrocarbons might have been accumulated in the high angle thrust faults developed along the pre-existing normal faults. The pre-existing normal fault traps underneath the shallow lower angle thrust belts and the gentle anticline structures associated with the lower Miocene stratigraphic traps in the foreland basin are the most favorable targets for future hydrocarbon exploration as well.