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ORIGINAL ARTICLE

Superimposed versus residual basin: The North Yellow Sea Basin

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Abstract The North Yellow Sea Basin is a Mesozoic and Cenozoic basin. Based on basin-margin facies, sedimentary thinning, size and shape of the basin and vitrinite reflectance, North Yellow Sea Basin is not a residual basin. Analysis of the development of the basin's three structural layers, self-contained petroleum systems, boundary fault activity, migration of the Mesozoic–Cenozoic sedimentation centers, different basin structures formed during different periods, and superposition of a two-stage extended basin and one-stage depression basin, the North Yellow Sea Basin is recognized as a superimposed basin.

1. Introduction

The study of oil-bearing sedimentary basin type has attracted increasing attention from petroleum geologists in recent years (Liu, 1997, 2007; Jia, 2006; Ding et al., 2009; Li et al., 2009a, 2010; Luo and Wu, 2010). Residual and superimposed basins are two key issues (Zhang, 1993; Wang and Mo, 1995; Lobkovsdy and Cloetingh, 1996; Mac, 1996; Sengor and Natalin, 1996; Liu, 2002; Zhou et al., 2002; He et al., 2004; Zhao et al., 2007; Tang et al., 2009). Due to the diversity of basin-forming environments and the complexity of their structural evolution, prototype features and their preservation are different in different basins or in different regions. There are also differences between the actual data recorded and theoretical models. However, understanding of the distinctive features and the identification criteria of each type of basin will insure that determination of the basin type is more objective and accurate.

The North Yellow Sea Basin is an important new area of oil and gas exploration in China and there have emerged different views on the nature and prototype of the basin (Cai, 1998; Li et al., 2003; Dai, 2003; Tian et al., 2004; Ma et al., 2005; Chen et al., 2006; Cao et al., 2007; Gong et al., 2009; Wang et al., 2010; Yuan et al., 2010). Based on our research (Li et al., 2006a,b, 2009b; Li, 2007), structural geometry and evolution, kinematics, and sedimentology, the prototype and existing type of the North Yellow Sea Mesozoic and Cenozoic Basin is discussed in this paper.

2. Geological setting

North Yellow Sea Basin is located in the southeast part of the Sino-Korean Plate. Following Paleozoic tectonism (Li, 1995;

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Feng et al., 2002; Lin et al., 2004), the basin formed as a result of multi-cyclic structural development and associated-deposition during the Late Jurassic−Early Cretaceous, Eocene−Oligocene, and Neogene. The basement of the basin comprises the Paleozoic sedimentary rocks and the Precambrian metamorphic rocks (Massoud et al., 1991, 1993). To the west, the basin is bounded by the transcurrent Tanlu Fault and to the south by the Sujiao−Linjin Orogenic Belt developed across the Jiao-Liao (China) and North Korea massifs. The overall trend of the basin is NE and the basinal area (west to 124° E) is 2.16×10^4 km^2 (Figs. 1 and 2).

North Yellow Sea Basin consists of six second-order and twenty-four third-order structural units (Fig. 3) (Li et al., 2006a). Eastern and central depressions of the basin are larger, and the maximum thickness of lacustrine deltaic Mesozoic−Cenozoic sediments is 8000−8400 m.

East-west − northeast, NW, and NNE-trending fold and fault structures developed in the North Yellow Sea Basin are the result of multiphase tectonism (Fig. 3). East-west−northeast-trending faults mainly developed in the Late Jurassic to the Early Cretaceous as a result of compression followed by tensional deformation. Cretaceous−Paleogene NW-trending faults are minor and poorly-developed in the eastern depression of the basin. NNE-trending normal-transcurrent faults with a large scale developed in the central and western parts of the basin formed in the Eocene, and may form the eastern and western boundaries of depressions or sags within the basin. Folding is characteristic of the central parts of these depressions, whereas monoclines are commonly developed at the margins of depressions or along bounding faults. Folds are comparatively well developed in the Mesozoic and Paleogene rocks that form the lower and middle parts of the basin, but are not developed in the Neogene sediments that form the upper parts of the basin.

3. North Yellow Sea Basin is not a residual basin

There are two types of residual basin, that it is a modified basin or that it represents the strongly modified remnant of a prototype basin. We prefer to the latter explanation. During their geological history, most sedimentary basins experience varying degrees of reformation. With minor reformation, the basin exhibits no major differences with the prototype basin so that the two are often difficult to distinguish. With more reformation, differences with the prototype basin are more obvious and the prototype basin can be characterized as a "residual" basin. In this article, a residual basin was defined as the residual part of the prototype basin that has been modified by post-basin formation moderate or strong uplift, erosion and reformation. Thus, future research should focus on the evidence of changing sedimentary process within the basin throughout its geological history.

Evidences to indicate that the North Yellow Sea Mesozoic and Cenozoic Basin is not a residual basin are described below.

3.1. Development of basin-margin facies

The most important feature of a residual basin is that after the formation of the prototype basin, extensive erosion of marginal coarse clastic sedimentary facies may occur. Although depressions within the North Yellow Sea Basin are separated by areas of uplifts, their margins are well developed with comparatively complete sedimentary sequences preserved. For example, the Late Jurassic−Early Cretaceous central depression (Fig. 2) is controlled by the EW to NNE-trending border faults to the south and north where sequences of marginal fan-delta and delta sediments are developed. During the Eocene, margin facies deposition of fan delta and alluvial fan sediments occurred within

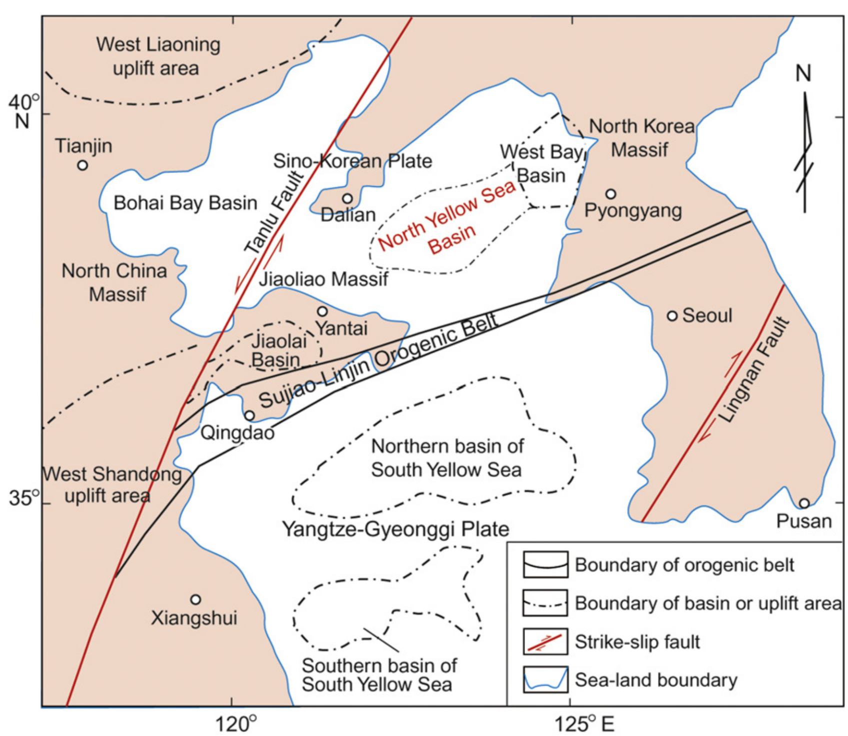

Figure 1 Regional tectonic location of the North Yellow Sea Basin.

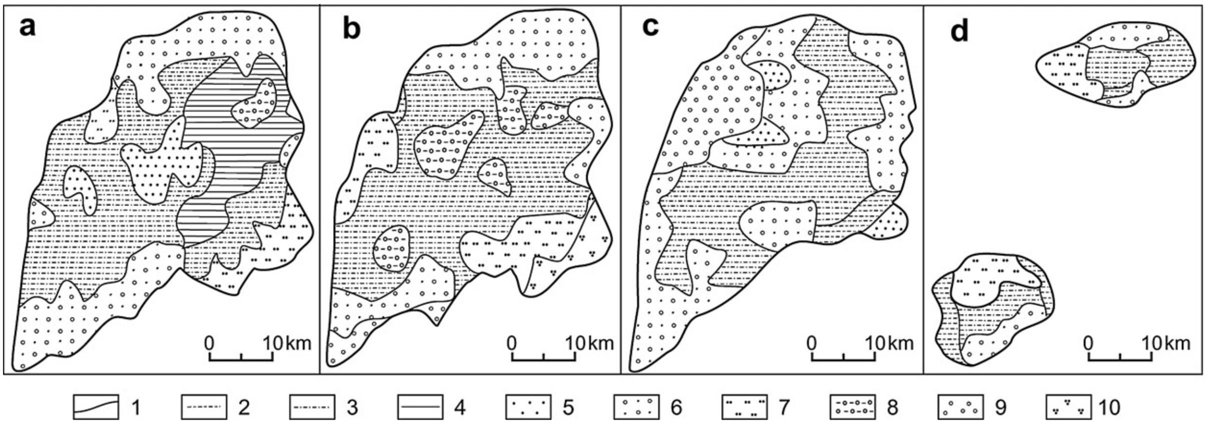

Figure 2 Sedimentary facies map of the central depression of the North Yellow Sea Basin. (a) Late Jurassic; (b) Early Cretaceous; (c) Eocene; (d) Oligocene. 1. Border facies field; 2. Shore lacustrine facies; 3. Shallow lacustrine facies; 4. Bathyal lacustrine facies; 5. Alluvial plain facies; 6. Fan delta facies; 7. Delta facies; 8. Turbidite fan facies; 9. Alluvial fan facies; 10. Fluvial facies.

a depression formed along an NNE boundary fault. During the Oligocene, re-activation of EW to ENE-trending faults also created deposition of delta and fan delta sediments.

3.2. Sedimentary thinning and stratal pinch-out

In a residual basin, from the basin center to the edge (graben-type basin), or from one side of the basin to the other (half-graben basin), there is no clear sedimentary thinning, stratal pinch-out and onlap phenomenon, in seismic profile. In addition, the sedimentary sequence is often uniformly uplifted so that the marginal sediments become strongly eroded. Several depressions within in the North Yellow Sea Basin show evidence of sedimentary thinning, stratal pinch-out and onlap relations. In the eastern depression, the Late Jurassic–Early Cretaceous sequence is thick in south but thins and pinches out to the north; Eocene–Oligocene sediments thin westwards and also pinch out. In the central depression of the basin, thick Late Jurassic–Early Cretaceous sediments thin to the west, whereas Eocene sediments thin toward the east. The western depression of the basin contains a maximum thickness of Late Jurassic–Early Cretaceous sediments in the southern part that thin northwards and eventually disappear. Eocene strata are thickest in the eastern area and thin westwards.

3.3. Basin area and shape consistent with the prototype basin

Another important feature of residual basins is that the residual parts, after being moderately or strongly reformed, are significantly reduced in area with a fundamental change in the basin shape, compared with that of the prototype basin. In some cases, the prototype basin has been transformed into a number of small basins. These small basins are regularly separated by a series of uplifts. According to the restoration of the prototype basin and the

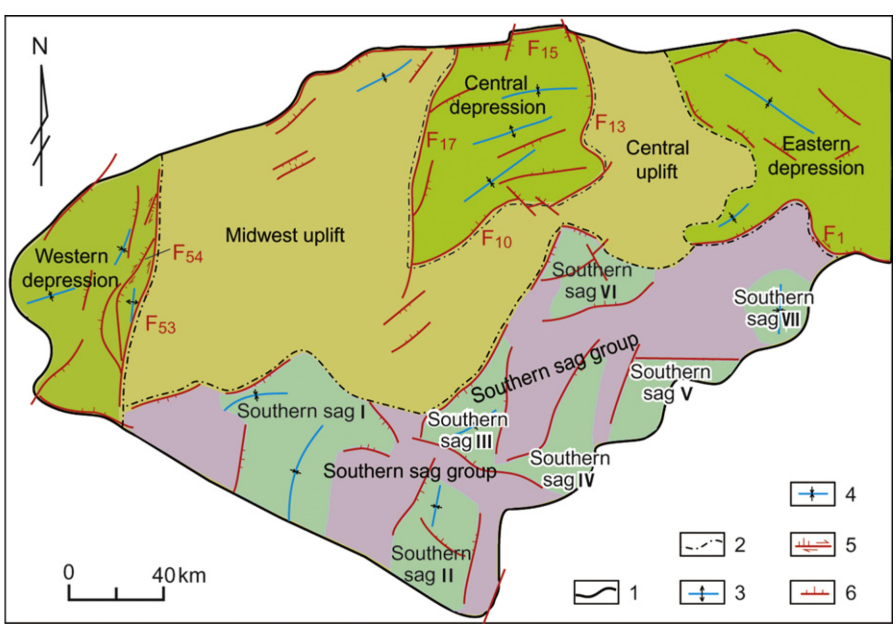

Figure 3 Tectonic elements and key structures of the North Yellow Sea Basin. 1. Basin boundary; 2. Boundary of second-order tectonic units; 3. Anticline; 4. Syncline; 5. Normal-strike-slip fault; 6. Normal fault.

evolution of the basin's tectonic history (Li et al., 2006a,b), the formation of the North Yellow Sea Mesozoic and Cenozoic Basin involved reformation of the early basins configuration, but the Mesozoic and Paleogene basin areas, size and shape underwent a little change, in which the general outline of the prototype basin remained the same. The North Yellow Sea Basin is characterized by a number of depressions with uplifts, which are inferred to represent individual residual basins that have been preserved after being strongly reformed. However, several sediment-filled depressions within the North Yellow Sea Basin retain primary Mesozoic sedimentary structures (Fig. 3). Reactivated boundary faults together with new faults controlled the location and thickness of the Paleogene sedimentation. Therefore, the North Yellow Sea Mesozoic and Cenozoic Basin should be called as the North Yellow Sea Basin Group viewed from the original forming features (Fig. 5).

3.4. Depth indicated by vitrinite reflectance matches the present depth

Sedimentary vitrinite reflectance R_o generally indicates the maximum burial depth of the sediment ever experienced. According to Massoud et al. (1991, 1993), the Upper Jurassic source rocks from wells 606 and 404 in the eastern depression of the North Yellow Sea Basin, contain mainly II-type kerogen, the Lower Cretaceous source rocks have II−III type kerogen, and the Paleogene source rocks contain II B-type kerogen. The vitrinite reflectance R_o of the Late Jurassic source rocks is 0.71−1.32, 0.5−0.8 for Early Cretaceous source rocks, and 0.4−0.6 for Paleogene source rocks. These values indicate sediment burial depths of 3350−2900 m, 3020−2150 m and 2300−1300 m, close to current depths of 3140−2800 m, 2600−2000 m and 1850−1200 m, respectively.

4. The North Yellow Sea Basin is a superimposed basin

A superimposed basin is a basin with complex structure due to vertical stacking of different basins (different structural layers). Basin development of each period have their independent prototype, the stacking of which reflects paleogeographic evolution and tectonism. Consequently, areas of post-deposition are different from those of pre-deposition, and pre-prototype basin are transformed as

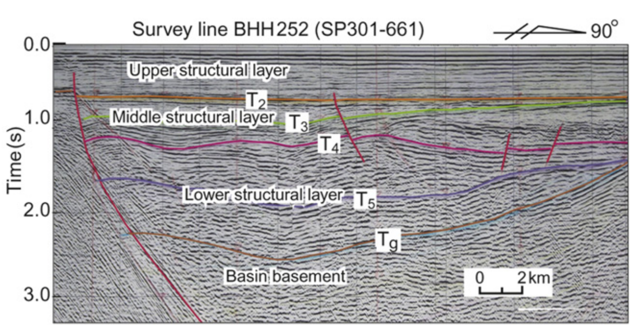

Figure 4 Seismic profile showing structural layers of the North Yellow Sea Basin. T_2−Unconformity between Neogene and Paleogene; T_3−Unconformity between Oligocene and Eocene; T_4−Unconformity between Cenozoic and Mesozoic; T_5−Unconformity between Cretaceous and Jurassic; T_g−Upper surface of Paleozoic.

well (Huang and Zhang, 2005). Compared with the residual basins, superimposed basins are "composite" basins. The prototype of the basins formed at different times may be preserved or transformed provided that there are at least two sets of differently aged sedimentary basins separated by the regional unconformity.

The North Yellow Sea Basin may be regarded as a superimposed Mesozoic and Cenozoic basin form the following evidence.

4.1. Development of three structure layers

The North Yellow Sea Basin has undergone regional deformation of Yanshan and Himalaya tectonism, which resulted in multi-cycle construction-sedimentation and the formation of several unconformities (Li et al., 2006b). The basin can be divided into three major structural layers: lower, middle and upper, according to seismic reflection characteristics, stratigraphic contacts, types of sedimentary filling and structural deformation, with regional unconformities (T_2, T_4 and T_g) reflecting major tectonic events (Fig. 4).

The lower structural layer comprises the strata between T_g and T_4, which are disconformable with the basement. The facies of the lower structural set consists of fluvial, lacustrine and deltaic sediments of the Late Jurassic−Early Cretaceous age. These sediments only occupy depressions in the southern area of the basin and are between 0 and 4700 m thick. Faulting to form EW−NE-trending horst and graben structure was clearly important for the development and evolution of the sedimentation depocenters.

The middle structural layer extends between unconformities T_4 and T_2, and has an angular unconformity contact with rocks of the lower structure layer. Alluvial fan, delta and lacustrine facies form the sedimentary sequence. The areal distribution of the middle layer is generally the same as the lower structural layer and varies in thickness from 0 to 4700 m. Movement on an NNE synsedimentary boundary fault was important for the formation of the middle structural layer.

The upper structural layer comprises the sediments between the T_2 angular unconformity and the present seafloor. The structural layer consists of poorly consolidated to unconsolidated lower lacustrine − delta facies and upper shore − shallow marine facies sediments. This structural layer occurs across the whole area of the North Yellow Sea Basin, and has a thickness of between 250 and 650 m. The underlying strata are the middle and lower structural layers (in depressions) or basement rocks (uplifted areas). The upper structural layer is essentially horizontal and/or is little deformed. Fractures are not developed and there are no intercalated igneous rocks.

4.2. Self-contained petroleum systems

Drilling data and analysis from the eastern part of the North Yellow Sea Basin collected by North Korea (Massoud et al., 1991, 1993) indicates that there are two kinds of petroleum-bearing systems, namely: Mesozoic and Cenozoic. The two petroleum reservoir systems are separated by a layer of mudstone at the base of the Eocene succession.

The source rocks of the Mesozoic petroleum system consist of the Late Jurassic shallow to moderately deep lacustrine black shale (primary source), and dark Early Cretaceous lacustrine shale (secondary source). Reservoir rocks are the Late Jurassic−Early Cretaceous alluvial fan, delta, turbidite fan and shore facies

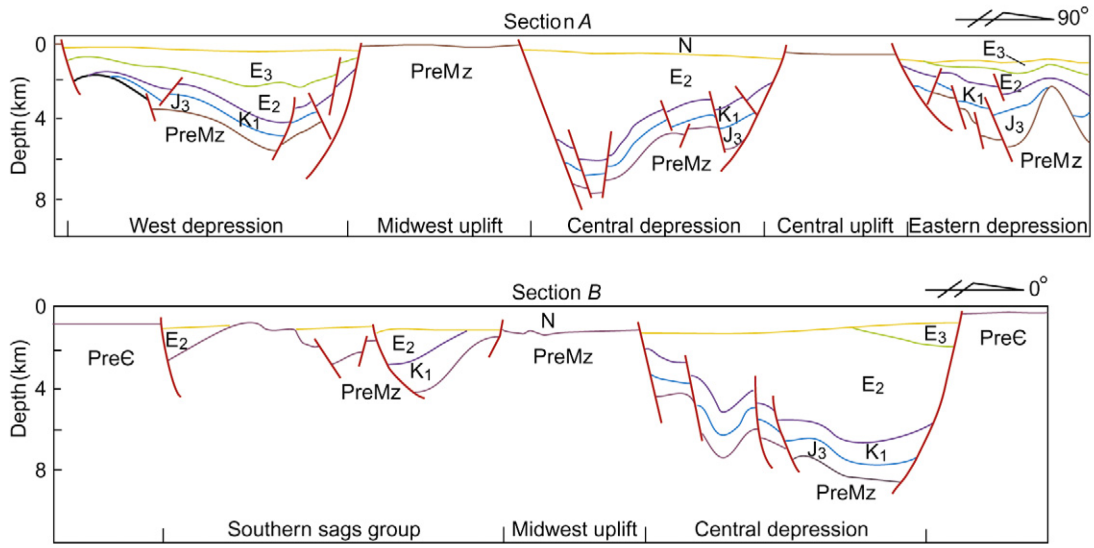

Figure 5 Profiles showing fault-controlled depression structures within the North Yellow Sea Basin.

sandstone, and fractured, weathered pre-Mesozoic basement rocks. The Eocene−Oligocene mudstone and the Late Jurassic−Early Cretaceous shallow-moderately deep lacustrine mudstone developed in depressions within the basin form both regional and local cover rocks. The eastern, central and the western depressions of the North Yellow Sea Basin form three separate hydrocarbon-bearing depressions or sub-petroleum systems.

The primary source rocks of the Cenozoic petroleum system comprise the Eocene shallow − moderately deep lacustrine mudstone. The Eocene sandstone of fan delta, delta, turbidite fan and shore facies is the reservoir with the Neogene and Oligocene basal transgressive mudstone forming the cap rock. Because of separation by faults and areas of uplift, this Cenozoic petroleum system also comprises three sub-petroleum systems, i.e., located within eastern, central, and western depressions.

4.3. Boundary faults with multi-phase activity

The boundary faults of the North Yellow Sea Basin trend approximately EW−NE and NNE. The EW−NE boundary faults are syn-sedimentary structures that mostly controlled the deposition of the Mesozoic sedimentation and form the north and south boundaries of the whole basin. These faults became reactivated in the Eocene and Oligocene and controlled the Paleogene deposition in the northern and southern parts of different depressions. The NNE faults, forming in the Eocene, are also synsedimentary and controlled the distribution of the Eocene sedimentation, especially that of the central, western and southern depressions. These faults were reactivated in the Oligocene and controlled the sedimentation pattern. The multi-phase activity of both sets of faults affected the sedimentary evolution of the North Yellow Sea Basin and reflects changes of the tectonic stress field during the Mesozoic and Cenozoic.

4.4. Different sediment deposition centers in the Mesozoic and Cenozoic

Superimposed basins had different deposition centers. During the Late Jurassic−Early Cretaceous, basinal development was controlled by EW−NE faults, and the largest sediment deposition center of the North Yellow Sea Basin was in the east depression in which some 4800 m of accumulation occurred. At the same time, sedimentary thicknesses in the western and two southern depressions were 3000 m, 1600 m and 1050 m, respectively. North-north-east faulting in the Eocene, caused the sediment deposition center to shift westward resulting in a maximum thickness of 5900 m accumulating in the central depression of the basin. Maximum coeval sediment thicknesses in the eastern, western and southern depressions were 4700 m, 3600 m, and 2400 m, respectively. Reactivation of NNE and EW−NE faults in the Oligocene resulted in further westward migration of the sedimentation deposition center, resulting in a maximum thickness of 2400 m in the western depression. Maximum Oligocene sediment thicknesses in the eastern, western, and southern depressions are 1200 m, 800 m, and 800 m, respectively.

4.5. Different basin structure in the Mesozoic and Cenozoic

Superimposed basins of different ages may have different structures because of changes in paleogeography and tectonic regime. The North Yellow Sea Basin is a typical example (Fig. 5). In the Late Jurassic−Early Cretaceous, the basin structure was determined by EW−NE faults to form deep and shallow horst and graben structures in the south and north, respectively. During the Eocene−Oligocene, NNE-trending faulting resulted in the formation of asymmetric grabens, such as central and southern depressions, in the eastern and western parts of the basin, and half-grabens such as the eastern and western depressions. Thermal subsidence of the North Yellow Sea Basin occurred throughout the Neogene, when sedimentation was characterized by interlayered sand and mud. The Neogene sequence is largely horizontal and is only weakly deformed. Generally, the Neogene sediments thin toward the basin periphery, resulting in onlapping.

4.6. Two-stage extended basin and one-stage depression basin

Superimposed basins involve the vertical stacking of sedimentary sequences and associated structures over time (Du et al., 1997; Hu et al., 2005; Reemst and Cloetingh, 2000). According to compaction curves shown in Fig. 6, in relation to the tectonic evolution of the North Yellow Sea Basin (Li et al., 2006b), the Mesozoic and Cenozoic basins have experienced three stages of

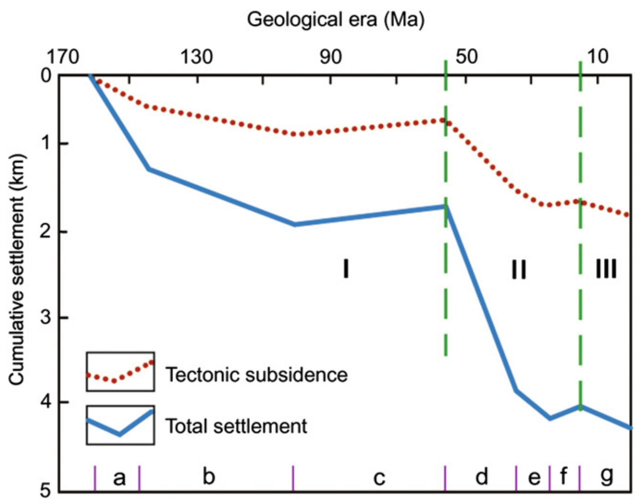

Figure 6 Compaction curves (red dashed line and solid blue line) for the North Yellow Sea Basin. I—Mesozoic extension faulted depression stage; II—Paleogene extension faulted depression stage; III—Neogene depression stage. a: Late Jurassic; b: Early Cretaceous; c: Late Cretaceous—Paleocene; d: Eocene; e: Oligocene; f: Early Miocene; g: Late Miocene—Holocene.

evolution, namely, a two-stage extensional basin and a one-stage depression basin. The Mesozoic (Late Jurassic—Early Cretaceous) is the first-stage of the extensional faulted basin and the Paleogene (Eocene—Oligocene) is the second stage, which involved modification of the first-stage basin. The thermal subsidence depression stage of the North Yellow Sea Basin occurred in the Neogene.

The above six features of the North Yellow Sea Mesozoic and Cenozoic Basin i.e., development of three structural layers, self-contained petroleum systems, boundary fault activity, migration of the Mesozoic—Cenozoic sediment deposition center, different basin structures formed at different periods, and superposition of a two-stage extended basin and a one-stage depression basin, are characteristics of superimposed basins, so that the North Yellow Sea Basin can be considered to be a typical example.

5. Conclusions

(1) Taking the North Yellow Sea Mesozoic and Cenozoic Basin as an example, the present study illustrates how to distinguish the basin as a residual basin or superimposed basin.
(2) Based on development of basin-margin facies, sedimentary thinning and pinch-out, basin area and shape being consistent with its prototype, vitrinite reflectance profiles that match current depths, the North Yellow Sea Mesozoic and Cenozoic Basin is not a residual basin.
(3) Analysis of the development of the basin's three structural layers, self-contained petroleum systems, multi-phase activity of boundary faults, migration of the Mesozoic and Cenozoic sedimentation centers, formation of different basin structures at different periods, and superposition of a two-stage extensional basin and a one-stage depression basin, the North Yellow Sea Basin is identified as a superimposed basin.

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References

Cai, Q.Z., 1998. Primary hydrocarbon-bearing basins and the pool-forming conditions in China seas and adjacent regions. Marine Geology & Quaternary Geology 18 (4), 1—10 (in Chinese with English abstract).

Cao, D.Y., Wang, X.G., Zhan, W.F., Li, W.Y., 2007. Subsidence history of the eastern depression in the North Yellow Sea basin. Journal of China University of Mining & Technology 17 (1), 90—95.

Chen, L., Bai, Z.L., Li, W.Y., 2006. The character of Meso-Cenozoic sedimental depression and oil-gas exploring direction in North Yellow Sea basin. Geophysical Prospecting for Petroleum 45 (3), 319—324 (in Chinese with English abstract).

Dai, M.G., 2003. Research progress in geology and geophysics characters of the Yellow Sea. Progress in Geophysics 18 (4), 583—591 (in Chinese with English abstract).

Ding, D.G., Wang, D.Y., Liu, Y.L., 2009. Transformation and deformation of the Paleozoic basins in lower Yangtze areas. Earth Science Frontiers 16 (4), 61—73 (in Chinese with English abstract).

Du, X.D., Qi, J.F., Lu, C.S., 1997. Application and present situation of subsidence backwards. World Geology 16 (2), 23—27 (in Chinese with English abstract).

Feng, Z.Q., Yao, Y.J., Zeng, X.H., Wang, Q., Wang, L.L., Chen, Q., Yi, H., Jin, H.F., 2002. New understanding of Mesozoic-Paleozoic tectonics and hydrocarbon potential in Yellow Sea. China Offshore Oil and Gas (Geology) 16 (6), 367—373 (in Chinese with English abstract).

Gong, C.L., Lei, H.Y., Wang, Y.M., Liu, Z.H., Guan, B.C., Hu, X.Q., Lu, J.B., 2009. Hydrocarbon geologic characters and structural evolution in the eastern depression of North Yellow Sea basin. Marine Geology & Quaternary Geology 29 (1), 79—86 (in Chinese with English abstract).

He, D.F., Jia, C.Z., Tong, X.G., 2004. Discussion and analysis of superimposed sedimentary basins. Petroleum Exploration and Development 31 (1), 1—7 (in Chinese with English abstract).

Hu, W.S., Lu, B.Q., Zhang, W.J., Mao, Z.G., Leng, J., Guan, D.Y., 2005. An approach to tectonic evolution and dynamics of the Songliao basin. China Journal of Geology 40 (1), 16—31 (in Chinese with English abstract).

Huang, Z.L., Zhang, L.B., 2005. A Dictionary of Earth Sciences—Applied Subjects. Geological Publishing House, Beijing, pp. 191—193 (in Chinese).

Jia, C.Z., 2006. The formation evolution of China superimposed basins and hydrocarbon exploration potential of their middle and lower combination. China Petroleum Exploration 11 (1), 1—4 (in Chinese).

Li, B.L., Wei, G.Q., Jia, C.Z., 2009a. Some key tectonics characteristics of Chinese foreland basins and their petroleum exploration. Earth Science Frontiers 16 (4), 190—202 (in Chinese with English abstract).

Li, N.S., 1995. Tectonic evolution of three structural basins in the Yellow Sea. Oceanologia et Limnologia Sinica 26 (4), 354—362 (in Chinese with English abstract).

Li, S.Z., Suo, Y.H., Dai, L.M., Liu, L.P., Jin, C., Liu, X., Hao, T.Y., Zhou, L.H., Liu, B.H., Zhou, J.T., Jiao, Q., 2010. Development of the Bohai Bay Basin and destruction of the North China Craton. Earth Science Frontiers 17 (4), 64—89 (in Chinese with English abstract).

Li, T.D., Mo, J., Xu, H., 2003. Geological structures and petroleum resources in Yellow Sea. China Offshore Oil and Gas (Geology) 17 (2), 79—88 (in Chinese with English abstract).

Li, W.Y., 2007. Tectonic deformation mechanism and geodynamic process of North Yellow Sea basin. Acta Geologica Sinica 81 (5), 588—598 (in Chinese with English abstract).

Li, W.Y., Li, D.X., Wang, H.J., 2006a. Research progress on structural geometry of the North Yellow Sea basin. Journal of Geomechanics 12 (1), 18−26 (in Chinese with English abstract).

Li, W.Y., Li, D.X., Xia, B., 2006b. Characteristics of structural evolution of North Yellow Sea Basin. Geoscience Journal of Graduate School, China University of Geosciences 20 (2), 268−276 (in Chinese with English abstract).

Li, W.Y., Zeng, X.H., Wang, X.G., An, Z.F., 2009b. Analysis of structural kinematics of North Yellow Sea basin. Earth Science Frontiers 16 (4), 74−86 (in Chinese with English abstract).

Lin, C.S., Zhang, Y.M., Li, S.T., Ren, J.Y., Zhang, Y.Z., 2004. Episodic rifting dynamic process and quantitative model of Mesozoic Cenozoic faulted basins in eastern China. Earth Science − Journal of China University of Geosciences 29 (5), 583−588 (in Chinese with English abstract).

Liu, C.Y., 2007. Geologic characteristics and petroleum accumulation conditions of superimposed basins. Acta Petrolei Sinica 28 (1), 1−7 (in Chinese with English abstract).

Liu, G.D., 1997. Preliminary discussion on residual basins. Petroleum Explorationist 2 (3), 1−4 (in Chinese).

Liu, L.F., 2002. A review of residual basin research. Progress in Geophysics 17 (4), 575−581 (in Chinese with English abstract).

Lobkovsdy, L.I., Cloetingh, S., 1996. Extensional basin of the former Soviet Union-structure, basin formation mechanisms and subsidence history. Tectonophysics 226, 251−285.

Luo, J.Q., Wu, C.D., 2010. Research of oil and gas exploration method accurately in the area of middle-high exploration level in the continental basin. Earth Science Frontiers 17 (4), 241−252 (in Chinese with English abstract).

Mac, D.S., 1996. Factors controlling the destruction or preservation of giant light oilfields. Petroleum Geoscience 2, 197−227.

Massoud, M.S., Scott, A.C., Killops, S.D., 1991. Oil source rock potential of the lacustrine Jurassic Sim Uuju formation, West Korea bay basin. Part: oil source rock correlation and environment of deposition. Journal of Petroleum Geology 14 (4), 365−386.

Massoud, M.S., Scott, A.C., Killops, S.D., 1993. Oil source rock potential of the lacustrine Jurassic Sim Uuju formation, West Korea Bay Basin. Part II: nature of the organic matter and hydrocarbon-generation history. Journal of Petroleum Geology 16 (3), 265−284.

Ma, W.T., Yu, W.H., Zhang, S.H., 2005. The structural features of North Yellow Sea basin and its evolution. Marine Geology Letters 21 (11), 21−27 (in Chinese with English abstract).

Reemst, P., Cloetingh, S., 2000. Polyphase rift evolution of the Voring Margin: constraints from forward tectonostratigraphic modeling. Tectonics 9 (2), 225−240.

Sengor, A.M., Natalin, B.S., 1996. The Tectonic Evolution of Asia. Cambridge University Press, Cambridge, pp. 256−282.

Tang, L.J., Huang, T.Z., Jin, W.Z., Lu, Z.Z., He, C.B., Ning, F., Wang, P.H., Chen, Q., 2009. Differential deformation and hydrocarbon accumulation in the superimposed basins. Earth Science Frontiers 16 (4), 13−22 (in Chinese with English abstract).

Tian, Z.X., Zhang, X.H., Xue, R.J., 2004. Regional geology features of the northern Yellow Sea basin. Marine Geology Letters 20 (2), 8−10 (in Chinese with English abstract).

Wang, H.Z., Mo, X.X., 1995. An outline of tectonic evolution of China. Episodes 18 (1), 6−16.

Wang, L.F., Wang, Y.T., Hu, X.Q., 2010. Stratigraphy and sedimentary characters of the western depression, North Yellow Sea basin. Marine Geology & Quaternary Geology 30 (3), 97−104 (in Chinese with English abstract).

Yuan, S.K., Wang, Y.M., Liu, Z.H., Luo, H., Zhu, Y.H., Li, Y.Y., Chen, L., 2010. Unconformity types and hydrocarbon accumulation models in the eastern depression of the North Yellow Sea basin. Petroleum Exploration and Development 37 (6), 663−667 (in Chinese with English abstract).

Zhang, J.H., 1993. Distinguishing criteria of relict basin and their significance in petroleum geology. Earth Science − Journal of China University of Geosciences 18 (6), 735−740 (in Chinese with English abstract).

Zhao, W.Z., Wang, Z.C., Zhang, S.C., Wang, H.J., 2007. The enrichment zones and accumulation condition of deep marine hydrocarbon in superimposed basins of China. Chinese Science Bulletin 52 (Suppl. I), 9−18.

Zhou, L.Q., Yang, S.L., Zhang, H., 2002. Characteristics of oil and gas reservoir systems in China's main marine residual basins. China Petroleum Exploration 7 (3), 31−38 (in Chinese with English abstract).