Late-stage Tectonic Inversion and Its Geodynamic Significance: Evidence from the Uplifting and Denudation History of the Songliao Basin*

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Abstract

The Songliao Basin is one of the largest lacustrine basins in the world. It was formed by Jurassic rifting, Early Cretaceous subsidence, and Late Cretaceous-Cenozoic inversion. The late-stage tectonic inversion resulted in the formation of the Daqing anticline in the central depression. Discovery of the Daqing Oil field has played an important role in both the development of the petroleum industry and the advancement of the nonmarine petroleum geologic theory of China (Figure 1).

Thickness of late-stage denudation has been reconstructed by means of vitrinite reflectance and porosity-depth relationships in shale. The inversion history has been unraveled by preparation of sequences along two regional cross-sections from the east margin to the west.

Research results indicate that the thickness of the denuded section is large in the east zone and small in the central depression zone and the west slope zone, thereby -showing a decrease in denudation from the east to the west. The estimated maximum thickness of 1650m is on the east margin, while the thicknesses of the west slope zone and the central depression vary between 400~600m, with the minimum thickness of 200m in the Gulong depression (Figure 2).

The denudation history, reconstructed from the two regional cross-sections, indicates that the late-stage tectonic inversion has undergone three stages of east-west migration. The tectonic inversion in the east occurred at the end of the Nenjiang period (77-73 Ma), while the tectonic inversion in the central depression began at the end of the Cretaceous (65 Ma) and extended to the early stage of the Eocene (45 Ma). Uplift of the west slope break zone, which was relatively slight, occurred at the end of the Paleogene (Figure 3).

The characteristics of the east-west variations of denudation and episodic uplift reflect the responses to a series of plate reorganizations

during the Mesozoic-Cenozoic. The first episode of the rapid uplift and denudation was in response to the subduction of the Izanazi Plate and later dissipation underneath the Eurasia Plate. The second episode was in response to major Yanshan Movement, when the moving direction of the Pacific Plate changed from NNW to NWW, and it orthogonally dived underneath the Eurasia Plate. The last episode was in response to the extension and closure of the Japan Sea (Figure 3).

References

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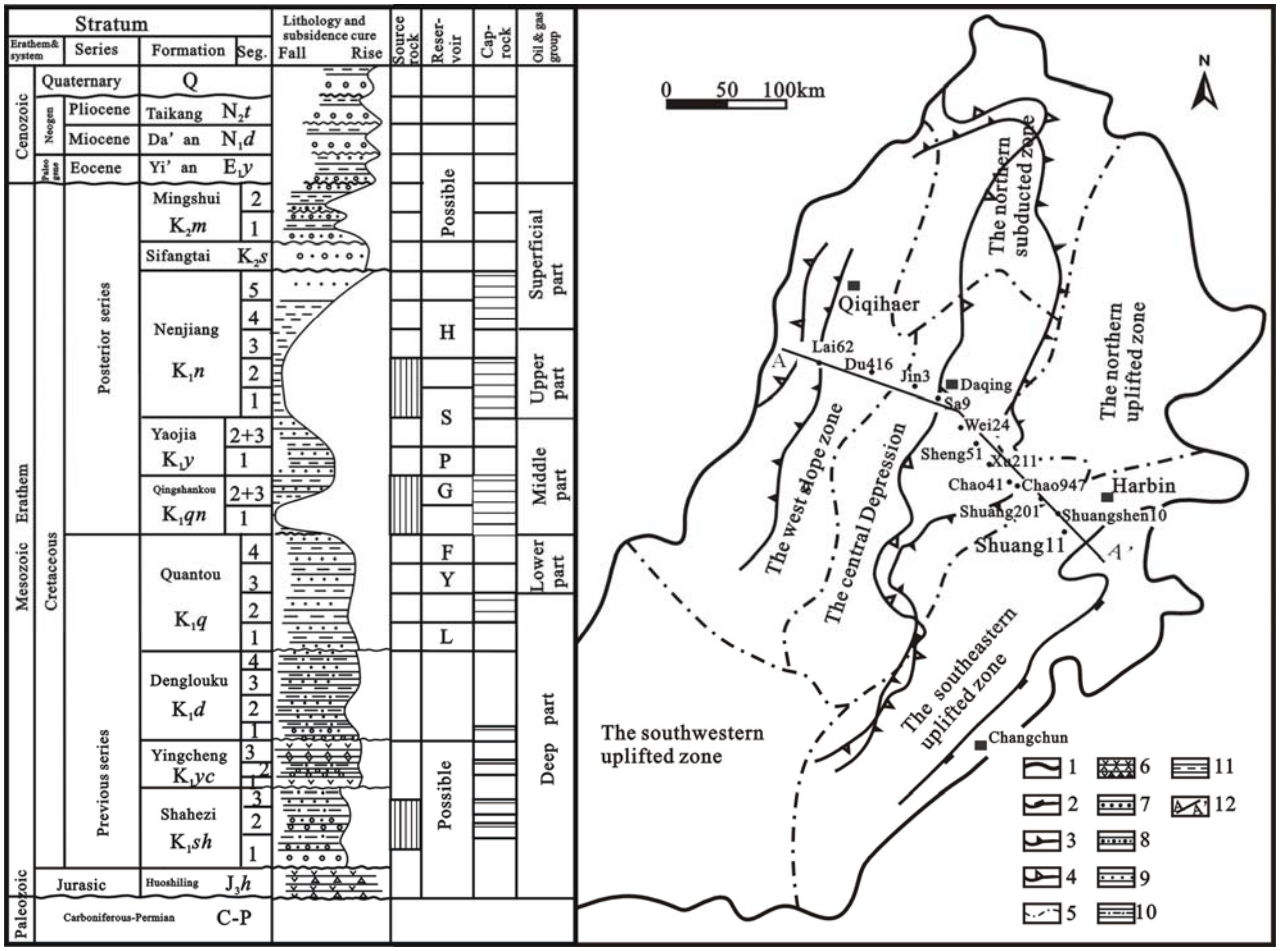

Figure1 Tectonic and sedimentary characters of the Songliao Basin, Northeast China.

1. Boundary of the basin; 2. Boundary of Nenjiang Formation; 3. Boundary of Late Cretaceous; 4. Boundary of Taikang Formation; 5. Tectonic boundary (see Yang et al., 1985, for detail); 6. Volcanic and pyroclastic rocks; 7. Conglomerate; 8. Glutinite; 9. Sandstone; 10. Sandy mud; 11. Mudstone; 12. Line of the profile in Figure 2.

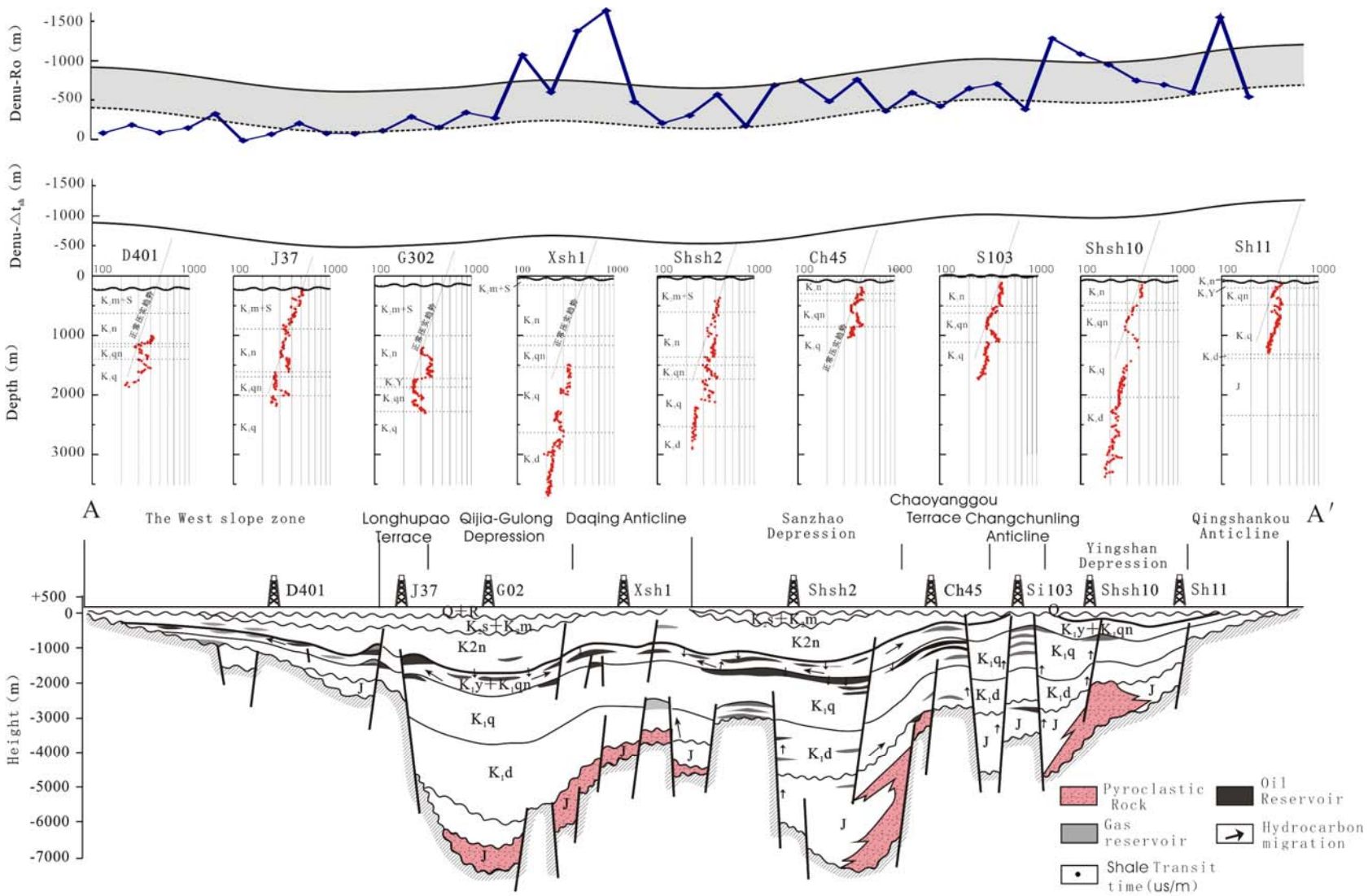

Figure 2. Differential uplift and denudation between the east and west parts of the Songliao basin. Data from both vitrinite reflectance and transit-time depth relationships in shale. Line of profile in Figure 1.

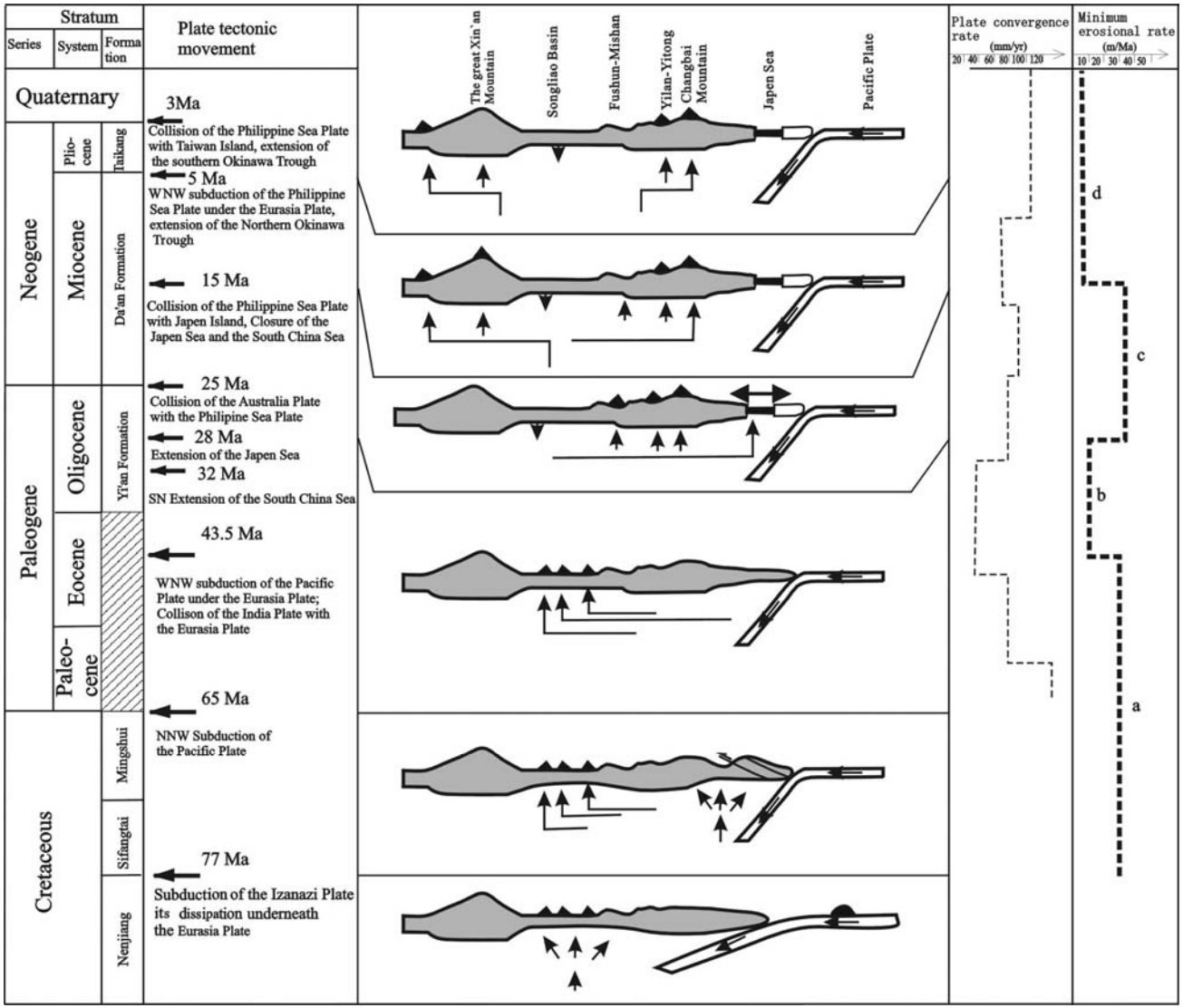

Figure 3 Correlation of late stage tectonic movements of the Songliao Basin with the subduction of the Pacific Plate underneath the Eurasia Plate. a-d are the minimum denudation velocity (reconstruction by AFT dating [Xiang et al., 2007]). a. The first stage of fast cooling; b. The first stage of slow cooling; c. The second stage of fast cooling; d. The second stage of slow cooling. Plate convergence rate of the Pacific Plate and the Eurasia Plate is from Ren et al. (2005).