Along-Strike Variability of Morphology and Sedimentation of the Northern Continental Margin of the South China Sea*

Haiteng Zhuo[1], Yingmin Wang[1], Qiang Xu[2], Dong Li[2], Yongfeng Wang[3], and Ying Wang[4]

Search and Discovery Article #50789 (2013)
Posted June 17, 2013

*Adapted from extended abstract prepared in conjunction with poster presentation at AAPG Annual Convention and Exhibition, Pittsburgh, Pennsylvania, May 19-22, 2013,

[1]College of Geosciences, China University of Petroleum, Beijing, Beijing, Beijing, China (zhuohaiteng@hotmail.com)
[2]CNOOC Research Institute, Beijing, Beijing, China
[3]Sinopec Management Institute, Beijing, Beijing, China
[4]CNOOC Shenzhen Limited, Guangzhou, Guangdong, China

Abstract

Analyses of a large amount of 2D and 3D seismic data permit a systematical investigation of the along-strike variations in the morphology and sedimentation of the northern margin of the South China Sea (SCS). Our results show that the studied margin can be divided into five sectors along depositional strike, which overlay the Yinggehai and western Qiongdongnan Basin (Sector 1), eastern Qiongdongnan Basin (Sector 2) and Pearl River Mouth Basin (Sector 3, 4 and 5). Each displays distinct characteristics in their relief, slope morphology, canyon development, and sequence stacking pattern as well as the resulting deposits. In general, the along-strike variability of the morphology and sedimentation of the northern SCS margin can be attributed to the regional and local structural style, sediment supply and marine extrinsic processes.

Introduction

As one of the hottest newly emerging frontiers, the northern continental margin of the South China Sea, underlain mainly by the Yinggehai, Qiongdongnan and Pearl River Mouth basins, has drawn worldwide attention for its huge hydrocarbon potential. Though widely documented, no attempt has been made to analyze the along-strike variability of this margin. This study uses an integrated dataset containing regional 2D seismic lines, high-resolution 3D seismic volumes as well as borehole data, to systematically investigate the variations on the morphology, sedimentation as well as the evolution history among the three major basins including the Yinggehai, Qiongdongnan and Pear River Mouth Basins which lie along the northern SCS margin.

Morphology and Continental Slope Zonation

The morphology of continental margin tends to evolve incrementally and cumulatively and reflects a relatively long-term formation processes (O'Grady et al., 2000; Praston et al., 2007). In this context, it is likely that the investigations of the slope shapes would give away useful

information to decode the slope's evolution history. The methodology of quantifying the submarine slope curvatures have been widely used in previous studies (Adams et al., 1998; Adams and Schlager, 2000; Covault et al., 2011). In this paper, the curvatures of continental slopes from eight seismic profiles, labeled line A to H (see location on Figure 1), were mainly used to zonate the northern SCS margin (e.g. Figure 2, Line A). Our results show that the studied margin can be divided into five sectors along the depositional strike, which overlay the Yinggehai and western Qiongdongnan Basin (Sector 1), eastern Qiongdongnan Basin (Sector 2) and Pearl River Mouth Basin (Sector 3, 4 and 5) (Figure 1). Each sector displays distinct characteristics in the relief, slope morphology, canyon development, and strata stacking pattern, as well as the resulting deposits.

Sector 1 is represented by line A, B and C (Figure 2). Continental slopes in Sector 1 have a moderate margin relief and the modern slope morphology can be fitted with an exponential equation, showing a concave-upward geometry. Sector 2, exemplified by line D and E, is featured by the steep slope and prominent shelf edges. The upper slope shows a planar geometry and can be well fitted using a linear equation. Sector 3 (line F) and Sector 5 (line G) lie on the two flanks of the Pear River Mouth area, having very high margin relief and the gentlest upper continental slope. A Gaussian distribution function can be applied to fit most of the slope profiles. Sector 4 (line H) resamples Sector 3 or 5 in most aspects except its concave-up slope profile. It is believed that some local factors such as higher sediment supply and canyon incision have caused this difference (Figure 2H).

Stacking Pattern and Sedimentation

The stacking pattern and the sedimentary characteristics are summarized in Figure 3. Due to sufficient sediment supply, Sector 1 is featured by rapid slope progradation and obvious shelf aggradation, leading to a long-term rising shelf edge trajectory (Figure 3A and B). Deep-water deposits are dominated by small-scale slumps and turbidites with short run-out distances. Submarine canyons are rare in both ancient and recent sequences. By contrast, Sector 2 is largely sediment-starved because of the large amounts of accommodation created by the activity of underlying faults since 10.5 Ma. The pre-existing fault caused the shelf edge trajectory to be fixed or slightly propagating. The sedimentation on this margin is characterized by densely distributed small-scale gullies in the upper slope and large-scale detached slump deposits in the lower slope (Figure 3C). Sectors 3, 4 and 5 are situated on the Pear River Mouth area, having very high margin relief and the gentlest upper continental slope. Truncations around the modern shelf edge reveal modifications of external forces to the morphology, such as internal waves and ocean currents (Figure 3D). Due to a longer duration, the shelf margin evolution of these sectors is very complicated; revealing combined structural and sedimentary influences. Submarine channel-fan systems have developed since 23.8 Ma, as proven by offshore drilling. Since 13.8 Ma, mature and tremendous submarine canyons have prevailed in central Pearl River Mouth basin.

Conclusion

This paper systematical analyzed the along-strike variations in the morphology and sedimentation of the northern margin of the South China Sea. Results show that this margin can be divided into five distinct slope sectors and each displays different characteristics in the relief, slope morphology, canyon development, stacking pattern as well as the resulting deposits. It is concluded that these along-strike variations can be attributed to the regional and local structural style, sediment supply and extrinsic processes.

References Cited

Adams, E.W., and W. Schlager, 2000, Basic types of submarine slope curvature: JSR, v. 70, p. 814-828.

Adams, E.W., W. Schlager, and E. Wattel, 1998, Submarine slopes with an exponential curvature: Sedimentary Geology, v. 117, p. 135-141.

Covault, J.A., A. Fildani, B.W. Romans, and T. McHargue, 2011,The natural range of submarine canyon-and-channel longitudinal profiles: Geosphere, v. 7/2, p. 313-332.

O'Grady, D.B., J.P.M. Syvitski, L.P. Pratson, and J.F. Sarg, 2000, Categorizing the morphologic variability of siliciclastic passive continental margins: Geology, v. 28/3, p. 207-210.

Pratson, L.F., C.A. Nittrouer, P.L. Wiberg, M.S. Steckler, J.B. Swenson, D.A. Cacchione, J.A. Karson, A.B. Murray, M.A. Wolinsky, T.P. Gerber, B.L. Mullenbach, G.A. Spinelli, C.S. Fulthorpe, D.B. O'Grady, G. Parker, N.W. Driscoll, R.L. Burger, C. Paola, D.L. Orange, M.E. Field, C.T. Friedrichs, and J.J. Fedele, 2007, Seascape evolution on clastic continental shelves and slopes, *in* C.A. Nittrouer, J.A. Austin, M.E. Field, J.H. Kravitz, J.P.M. Syvitski, and P.L. Wiberg, (eds.), Continental margin sedimentation; from sediment transport to sequence stratigraphy: Special Publication of the International Association of Sedimentologists, v. 37, p. 339-380.

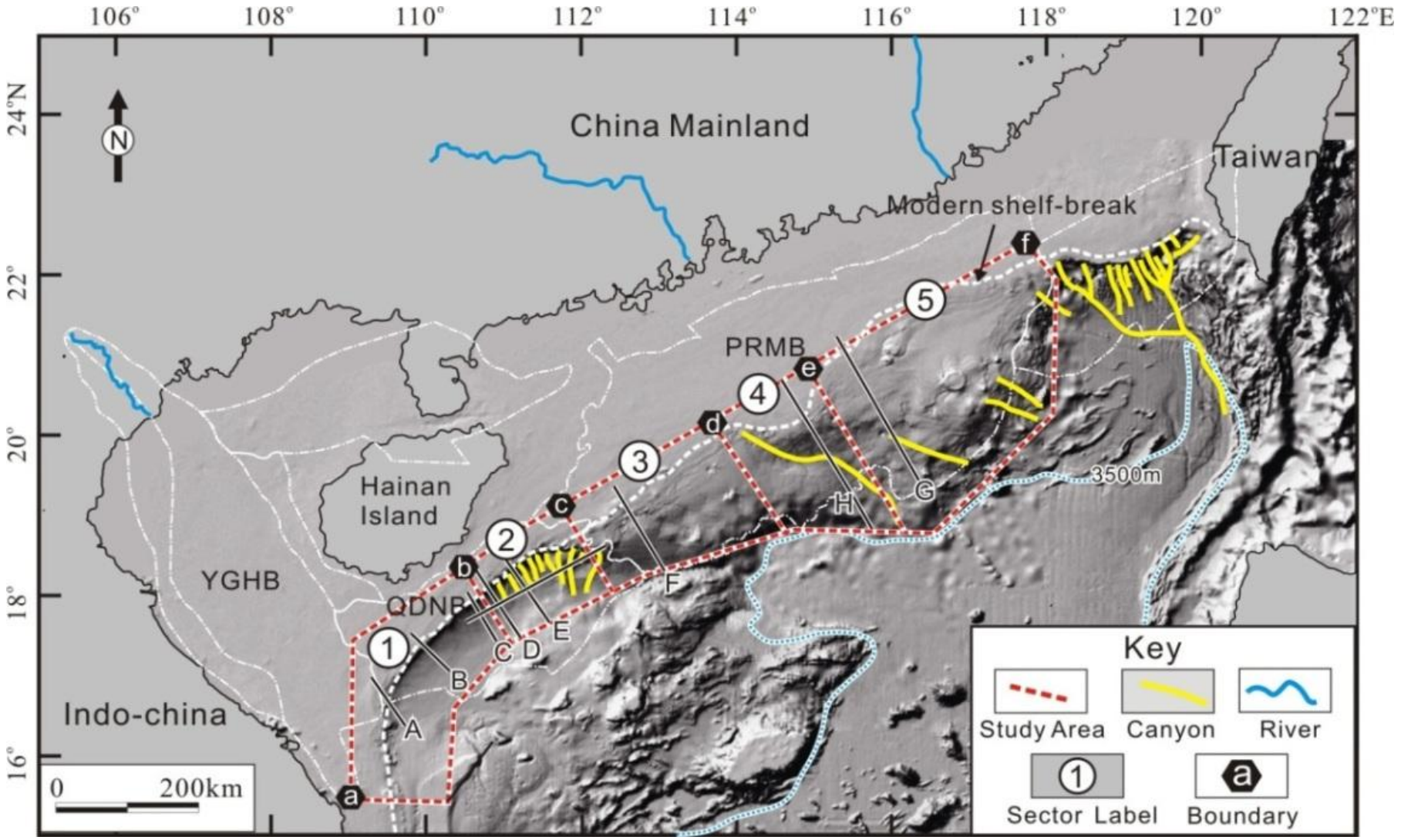

Figure 1. Index map of the study area, showing the regional seismic lines used in this study and the slope sectors. YGHB-Yinggehai Basin; QDNB-Qiongdongnan Basin; PRMB-Pearl River Mouth Basin.

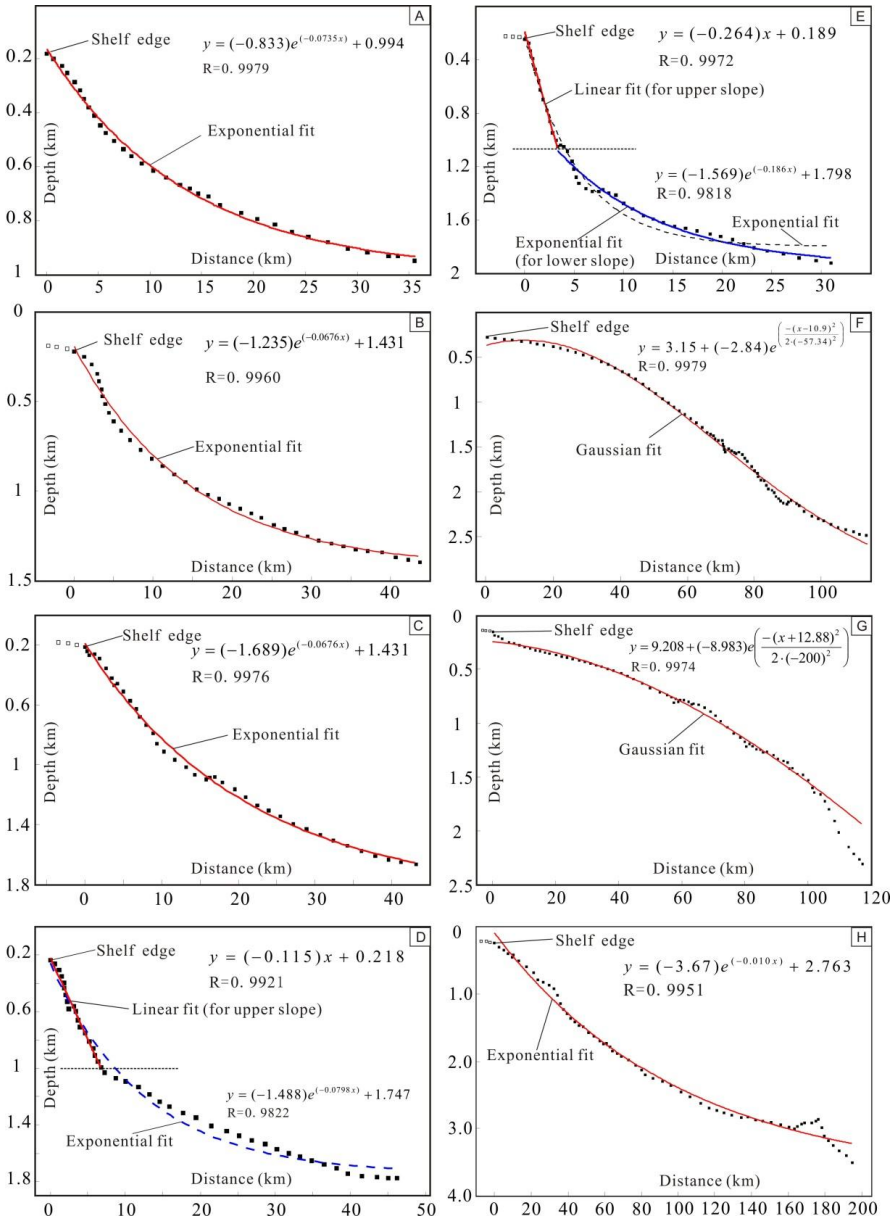

Figure 2. Curve-fitting results of for the selected seismic lines (see location on Figure 1).

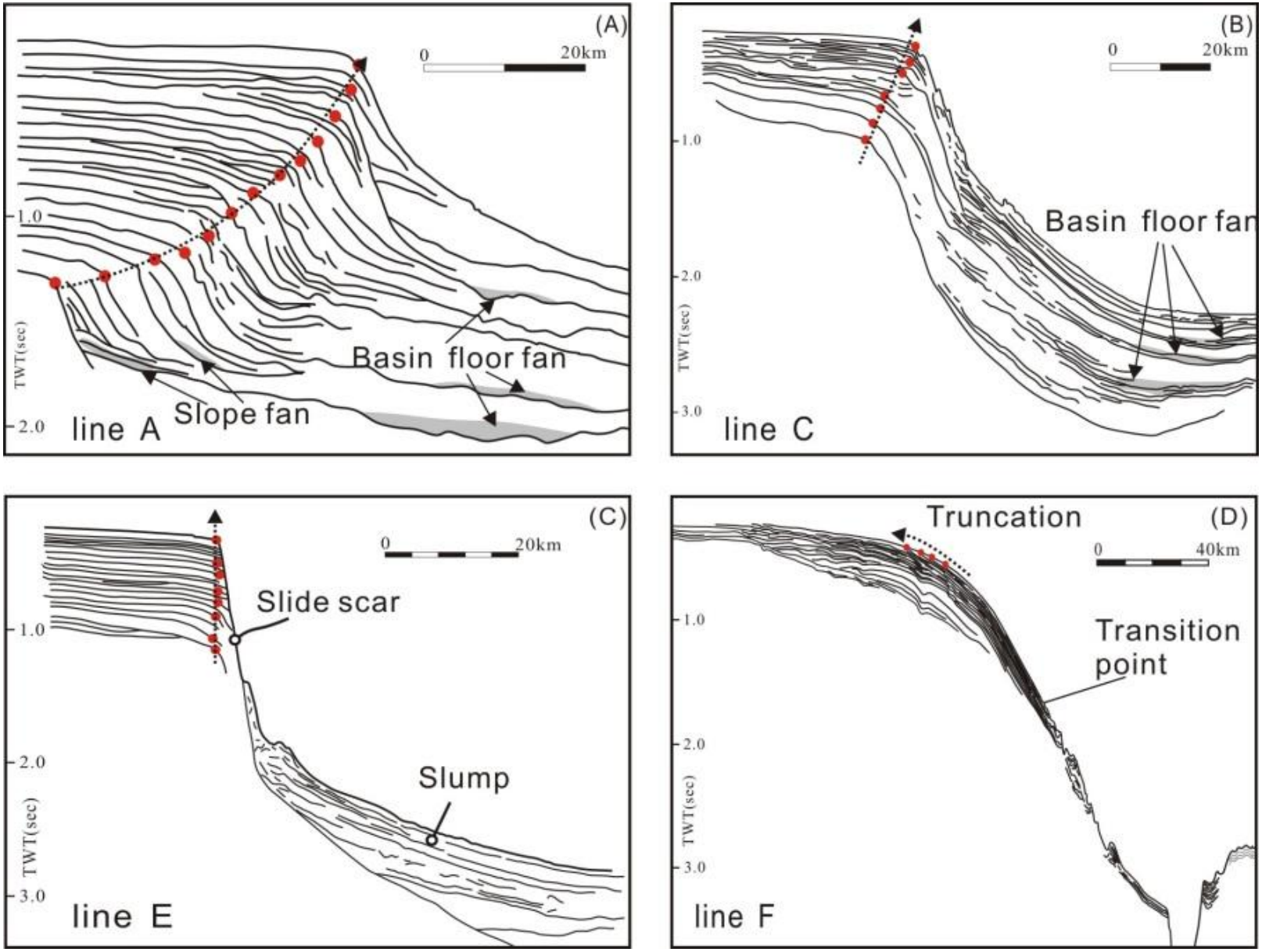

Figure 3. Stacking patterns and shelf-edge trajectory tend in the northern South China Sea margin.