

Rift Basin-Fill Architecture of Fluvial-Lacustrine Lower Permian Lucaogou and Hongyanchi Low-Order Cycles, NW China

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Abstract

Rapid lateral facies change, autogenic processes, and irregular topography of continental rift basins challenge the reconstruction of basin-fill architecture. A process-based approach, using interpreted climatic and tectonic controlling processes on sedimentation in addition to observable attributes, may be useful to correlate sedimentary cycles. This hypothesis is tested for Lower Permian Lucaogou and Hongyanchi low-order cycles (LCs) in the Tarlong-Taodonggou half-graben, using outcrop and petrographic data. The fluvial-lacustrine graben fill covers 88 km².

Depositional environments and controlling sedimentary processes were interpreted on 5 measured sections, 0.2-5 km apart. Lucaogou LC has a transgressive base over underlying alluvial-fan deposits of the Daheyan LC. The Lucaogou LC is composed of deepwater deposits interspersed with deltaic deposits. The top of Lucaogou is an erosional unconformity overlain by fluvial deposits of basal Hongyanchi LC, followed upward by deepwater deposits. It is capped by a graben-wide fluvial erosional unconformity overlain by paleosols and fluvial deposits of the Quanzijie LC.

Introduction

Complex stratigraphic relationships of nonmarine basin-fills challenge the application of traditional marine sequence stratigraphic techniques (Talbot and Allen, 1996; Carroll and Bohacs, 1999; Yang et al., 2009). Stratigraphic architecture may be reconstructed with a process-based approach, that is, using interpreted climatic and tectonic controlling processes on sedimentation in addition to observable attributes to correlate sedimentary cycles. This hypothesis is tested for Lower Permian Lucaogou and Hongyanchi low-order cycles (LCs) in the Tarlong-Taodonggou half-graben, southern Bogda Mountains, NW China (Figure 1).

The sequence stratigraphic architecture is the foundation for reconstructing paleogeography, paleoclimate, and tectonics. Fluvial-lacustrine depositional environments and controlling tectonic and climatic processes were interpreted in the field study area. Microscopic and XRD data on grain composition and texture from collected limestones, sandstones, shales, and paleosols substantiate field interpretations and minimize stratigraphic miscorrelation. Humid to arid climatic conditions are interpreted using climate-sensitive lithologies, such as paleosols; tectonic movement are interpreted in terms of source area uplift, basin subsidence, and spill-point movement (Figure 1).

Results

The base of Lucaogou is transgressive over underlying alluvial-fan deposits of the upper Daheyan LC. Transgressive beach sandstones contain superficial ooids, suggesting lake expansion was accompanied by evaporative conditions in a semi-arid climate, similar to Great Salt Lake. The Lucaogou LC is composed of fluctuating profundal lacustrine siliciclastic and carbonate deposits, containing ostracods, charophytes, algae, and fish fossils, interspersed with deltaic deposits. Thickness and facies relationships suggest a fluvial-deltaic and shallow lacustrine depocenter in the SW, deepening to the NE.

The top of Lucaogou is a fluvial-deltaic erosional unconformity, across which the type and magnitude of facies shifts varies greatly across the half-graben. Regionally, the boundary indicates a drastic shift from a widespread, NE-deepening lake during uppermost Lucaogou time to lake contraction, fluvial incision and regression in the north, and transgressive beach and deltaic systems in the south in early Hongyanchi time.

The overlying Hongyanchi LC is composed of fluvial deposits in the basal part and fluctuating profundal siliciclastic and carbonate deposits upward. The uppermost Hongyanchi deposits show evidence for exposure, pedogenesis, and vadose zone infiltration of groundwater, including pendant and meniscus cements, root molds, and formation of rounded soil peds with illuvial clays. It is capped by a graben-wide fluvial erosional unconformity overlain by mature Calcisols and red mudstones of the Quanzijie LC.

Conclusions

The Daheyuan-Lucaogou-Hongyanchi LCs constitute a sequence of deposits similar to other rift basins. During rift initiation, the rift valley fills with alluvial fan deposits, similar to those of Death Valley (Daheyuan time). As rifting continues, the bordering mountains become large, confining the basin and allowing for lakes to develop (Lucaogou/Hongyanchi time). The lakes become filled with sediment over time as rivers feed deltaic systems, and the topography becomes more flat (end-Hongyanchi time).

The process-based depositional model may be useful to paleogeographic reconstruction of other nonmarine rift basin fills, and contribute to the understanding of the relationship between the distribution of sedimentary facies with basin topography, climate, and tectonics. Finally, the outcrop and petrographic results provide data and analogs on the quality and distribution of hydrocarbon source and reservoir rocks in the adjacent petroliferous Turpan and Junggar basins.

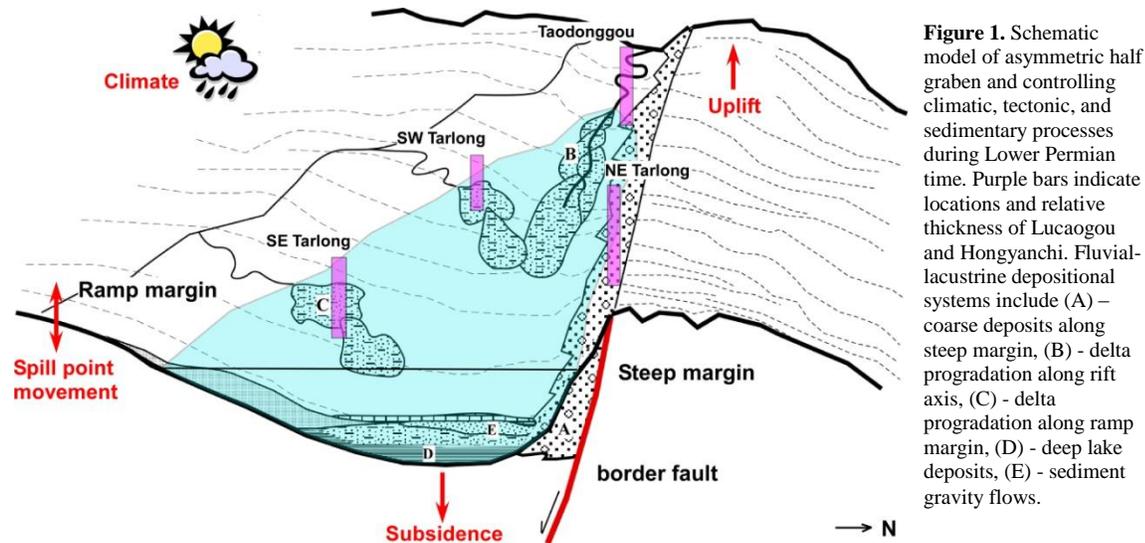


Figure 1. Schematic model of asymmetric half graben and controlling climatic, tectonic, and sedimentary processes during Lower Permian time. Purple bars indicate locations and relative thickness of Lucaogou and Hongyanchi. Fluvial-lacustrine depositional systems include (A) – coarse deposits along steep margin, (B) - delta progradation along rift axis, (C) - delta progradation along ramp margin, (D) - deep lake deposits, (E) - sediment gravity flows.

Acknowledgements

I would like to thank Wei Guan for his support in the field, laboratory, and international travel to the remote field area. We thank Wei Li, Qian Yao Wang, J. Li, X. Cheng, H. Tian, W. Chen, D. Fu, W. Li, Neil Tabor, for field assistance. The project was partially supported by the Kansas Geological Foundation.

References

- [1] Carroll, A.R., and Bohacs, K.M., 1999, Stratigraphic classification of ancient lakes: Balancing tectonic and climatic controls. *Geology*, v. 27, 99-102.
- [2] Talbot, M.R., and Allen, P.A., 1996, Lakes, in Reading, H.G., ed., *Sedimentary environments: processes, facies and stratigraphy*. Blackwell Science, London, 83-124.
- [3] Yang, 2009, *Depositional Environments and Cyclo- and Chronostratigraphy of Uppermost Carboniferous-Lower Triassic Fluvial-Lacustrine Deposits, Southern Bogda Mountains, NW China – A Terrestrial Paleoclimatic Record of Mid-Latitude NE Pangea*: in press, *Global and Planetary Changes*.