Nature and Origins of a Stratigraphic Boundary in a Continental Setting, Southern Bogda Mountains, NW China

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Abstract

A nonmarine stratigraphic boundary where major facies shifts occur indicates drastic changes in environmental conditions, but may have highly variable magnitude of facies shifts to rapid lateral facies changes, common autogenic processes, and irregular topography. This hypothesis is tested for the boundary separating fluvial-lacustrine Lower-Permian Lucaogou and Hongyanchi formations, deposited in a continental rift setting. The boundary is identified on 5 stratigraphic sections 0.2-5 km apart over ~80 km^2 area, NW China.

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. Lake contraction may be caused by climatic change, tectonic processes including volcanism, and/or sediment infilling of the lake basin.

Introduction

A stratigraphic boundary where major shifts in depositional environments occur indicates drastic changes in environmental conditions, and is critical to time-stratigraphic analysis. The boundary in nonmarine strata may have highly variable magnitude of facies shifts in different parts of a continental rift basin due to rapid lateral facies changes, common local processes, and irregular topography intrinsic to nonmarine environments (Talbot and Allen, 1996; Carroll and Bohacs, 1999; Yang et al., 2009). This hypothesis is tested using a boundary separating Lower-Permian Lucaogou and Hongyanchi formations, deposited in the Tarlong-Taodonggou half graben, exposed in the southern BogdaMountains, NW China. The graben fill covers ~80 km^2. An accurate time-stratigraphic framework will allow a more accurate reconstruction of stratigraphic architecture, paleogeography, and basin-filling history.

Results

The boundary is identified by major shifts of depositional environments on 5 sections 0.2-5 km apart. In Taodonggou, braided stream deposits downcut older shallow-water deposits. In NE Tarlong, braided and coarse meandering stream deposits downcut deep-water deposits, suggesting a fluvial valley at the boundary. Fluvial overbank deposits overlie deep-water deposits 0.2 km to the west, and .5 km further to the west the boundary becomes conformable, separating deep-water deposits from overlying transgressive beach and deltaic deposits. In SE Tarlong, a transgressive surface separates deep-water deposits from overlying thick beach pebbles and deltaic deposits, suggesting a deltaic depocenter at the boundary. In SW Tarlong, deltaic deposits are overlain by transgressive beach and shallow- to deep-water deposits.

The fact that strata thicken to the NE suggests asymmetric sediment infilling of a half graben (Fig. 1). The uppermost Lucaogou trend of deepening to the NE may indicate that NE Tarlong is along the steep margin, and SW Tarlong is along the ramp margin of the half graben (Fig. 1). Regionally, the boundary indicates a drastic shift from a widespread, NE-deepening lake during uppermost Lucaogou time (Fig. 2a) to major lake contraction, fluvial incision in Taodonggou and NE Tarlong, and deltaic progradation in SE Tarlong during early Hongyanchi time (Fig. 2b). Source uplift to the north is indicated by regression and significant erosion at the boundary in Taodonggou and NE Tarlong and transgression in SE and SW Tarlong. Southward tilting of the lake basin would cause northern regression and southern transgression, as seen in the modern YellowstoneLake, which has been tilted due to volcanic dome uplift.

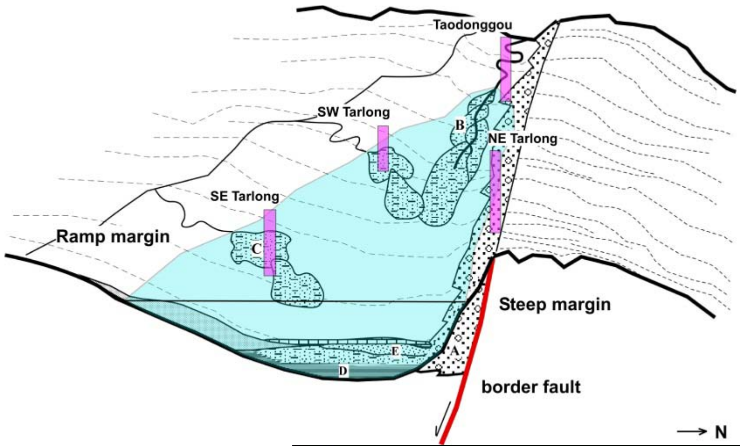

Figure 1. Schematic model of asymmetric half graben during Lower Permian time.Purple bars indicate locations and relative thickness of Lucaogou and Hongyanchi. Fluvial-lacustrine depositional systems include (A)–coarse deposits along steep margin, (B) - delta progradation along rift axis, (C) - delta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

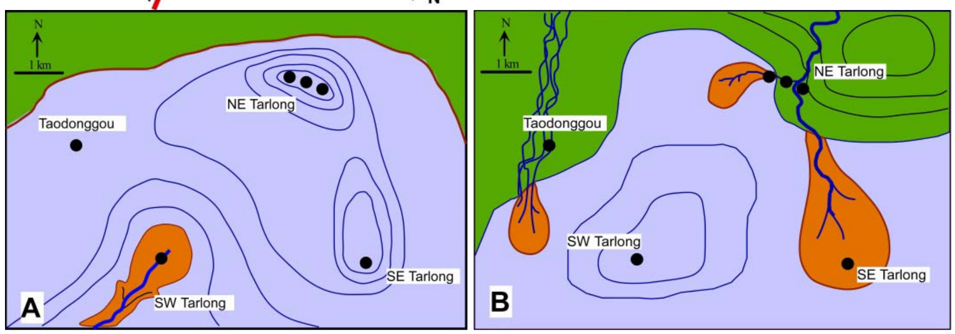

Figure 2. Paleogeographic reconstruction of (a) uppermost Lucaogou, and (b) basal Hongyanchi.

Conclusions

The uppermost Lucaogou lake deposits record a widespread, balance- to overfilled lake in a subhumid to humid climate, and a rapidly subsiding basin floor. Lake expansion may have been caused by increased precipitation and runoff to the basin, lake-margin subsidence, uplift of the spill point, and/or damming of the spillway by volcanic or glacial deposits. Causes for major lake contraction across the Lucaogou-Hongyanchi boundary include increased aridity, sediment infilling, a catastrophic spill-point lowering event such as a dam break, and/or uplift of the lake margin by means of rift tectonics. The lack of arid climate indicators, and abundance of coarse clastics in basal Hongyanchi deposits indicate large perennial river inflow in a humid, seasonal climate. Tectonic movement may be a likely cause for lake contraction, such as volcanic doming, as indicated by tuff and rhyolitic deposits a short interval above the boundary. Volcanic doming may have tilted the lake to the south, causing regression in the northern margin and transgression in the southern margin. Major lake contraction at the boundary is followed by gradual lake expansion, forming a widespread Hongyanchi lake. A thorough understanding of local and regional sedimentary, climatic, and tectonic processes and basin topography is critical to identifying and correlating major nonmarine stratigraphic boundaries.

References

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