

Fluvial and Lacustrine Depositional Systems and Cyclostratigraphy of Upper Permian Wutonggou Formation, Southern Bogda Mountains, NW China

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Introduction

The discovery of thick organic-rich lacustrine shales in the Upper Permian strata has brought much attention to the Bogda Mountains in the last two decades [1]. The Bogda Mountains is located in the east part of the Xinjiang Uygur Autonomous Region, People's Republic of China and contains excellent exposures of intermontane basin deposits. The Bogda Mountains separate the Turpan-Hami Basin to the south and the eastern Junggar Basin to the north. The Turpan-Hami Basin is a major physiographic feature of northwest China; it sits at 154 m below sea level, making it the second lowest land surface on earth.

The study area is located on the southern slope of the Bogda Mountains, where Permian to Mesozoic non-marine sedimentary strata is superbly exposed. The Upper Permian Wutonggou Formation is 240 m thick and is suggested to be composed of fluvial, lacustrine-deltaic, and lacustrine non-deltaic depositional systems [2]. The depositional cycles recorded a complex interplay of climate, sedimentary processes, and tectonic movement of provenance and depositional sites in the basin. This study establishes a high-resolution cyclostratigraphy of the Wutonggou Formation through cm-m-scale field observations and interpretation of fluvial-lacustrine depositional systems. The cyclostratigraphy is needed for a better systematic understanding of sedimentary processes, tectonic movement, and climate in nonmarine sedimentary systems [3]. This is one of the first high-resolution cyclostratigraphy of Upper Permian sections in eastern Central Asia.

Methodology

A sedimentologic and stratigraphic field study of the Upper Permian Wutonggou Formation was conducted. The thickness, lithologies, fossils, sedimentary structures, stratal geometry and boundary relationships were recorded; samples were collected for further laboratory study to refine field interpretations. The rock samples were cut into slabs, which were examined under microscope. This permitted thorough examination of lithology, grain size and shape, sedimentary texture and structure, and fossils. The depositional environments of individual sedimentation units were interpreted from lithology, sedimentary texture and structure, fossil type and abundance, stratal geometry, and boundary types. The depositional cycles were then identified from the systematic changes of the interpreted depositional environments. The field and lab data were used to construct the stratigraphic section of the Wutonggou Formation.

Results

Fluvial deposits of meandering streams were interpreted from upward-fining successions of orthoconglomerate, lithic wacke to subarenite, and mudrock. Coarse-grained deposits have large scale tabular and trough cross-beddings, internal erosional surfaces, and channel shaped erosional surfaces. They are lenticular with rapid lithologic and thickness changes. Mudrock includes shale, carbonaceous shale, coal, and mudstone. Lacustrine-deltaic deposits were interpreted from upward-coarsening successions of shale, cross-bedded lithic wacke to arenite, channel-fill conglomeratic sandstone overlain by pedogenetically altered mudrock, and petrified wood. Overall upward-fining successions of carbonaceous shale, granular orthoconglomerate, lithic and feldspathic arenite, well-laminated shale, and fossiliferous limestone were interpreted as littoral lacustrine systems. Coarse-

grained deposits are well sorted, plane or cross-bedded, laterally persistent with sharp non-erosional to slightly erosional bases, and were interpreted as transgressive lakeshore deposits. The well-laminated shale and limestone were interpreted as littoral deposits.

Cyclostratigraphy of individual fluvial and lacustrine systems constitute 91 high-order depositional cycles (average 2.5 m thick). Commonly 3-6 high-order cycles show upward-thickening and/or fining trends, forming 9 intermediate-order cycles. The overall similarity in stacking patterns of intermediate cycles was used to identify 3 low-order cycles. Cycle hierarchy indicates systematic tectonic and climatic processes controlling cycle formation. The multi-order cycles form the foundation to establish a regional cyclostratigraphic framework.

Significance

The high-resolution cyclostratigraphy of the Wutonggou Formation in the Taoshuyuan section, established through cm-m-scale reconstruction of fluvial-lacustrine depositional environments is one of the first Permian sections in eastern Central Asia. The dm-m-scale lake expansion-contraction cycles and fluvial cycles are stratigraphic entities that record complex interplay of climate, tectonic movement of provenance and depositional sites in the basin, and sedimentary processes. They formed the basis to establish models of cyclic sedimentation of nonmarine depositional systems in intermontane basins under mid to high-latitude climate conditions. The models will be useful to sedimentologic and stratigraphic studies in other Phanerozoic intermontane basins worldwide.

Currently, the information is very limited in eastern Central Asia and is critical to paleogeographic and paleoclimatic reconstructions of this region. A time-stratigraphic framework is essential to future studies on paleogeography, and paleoclimate.

Finally, the studied section contains a variety of hydrocarbon source rock and reservoir rock associations. Field investigation of depositional systems and laboratory petrographic study of collected samples have provided important information on the spatial geometry, continuity, compartmentalization, and relationship of source and reservoir rocks as well as quality of reservoir rocks. The results will aid significantly in hydrocarbon exploration and exploitation in the adjacent petroliferous Turpan-Hami and eastern Junggar basins.

Conclusion

The Upper Permian Wutonggou Formation consists of a variety of depositional systems. Fluvial systems include coarse-grained and classic meandering stream deposits, composed of conglomerate, sandstone, siltstone, and shale. Lacustrine systems include deltaic and littoral siliciclastic-carbonate systems. Carbonaceous shale and coals were developed in the floodplain and deltaplain deposits. The depositional systems are grouped into three orders of depositional cycles on the basis of stratigraphic trends of depositional environment changes. Low-order cycles and some intermediate-order cycles can be correlated over a distance of 10 km, but many high-order cycles can not be correlated due to common lateral facies changes. All cycles are stratigraphic entities of sediment deposition and erosion, controlled by interplay of genetically-related sedimentary, tectonic, and/or climatic processes.

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