

Relationship between Litho- and Organo-Facies of Lower Permian Lucaogou Low-Order Cycle, Southern Bogda Mountains, Greater Turpan-Junggar Rift Basin, NW China

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ABSTRACT

Organic matter (OM) is controlled by both production and preservation which are intimately associated with depositional and diagenetic processes. Productivity of phytoplankton in the surface waters and efficiency of nutrient recycling within the aquatic systems are major controls on the type and abundance of OM. In addition, preservation of OM is controlled by alteration from oxidation and bioturbation in the water column and sediment surface and diagenesis of the organic particles. Lithofacies and the amount and type of inherent OM are closely associated. Hence, litho- and organo-facies control the type and amount of petroleum generation during burial. Organic geochemical proxies derived from distributions and abundance of specific biomarkers extracted from 128 lacustrine shale samples from five sections of Lucaogou low-order cycles (LCG LC) have been used to describe thermal maturity of OM and investigate depositional and diagenetic processes of lacustrine shale.

Bulk geochemical indices and molecular biomarkers are interpreted with the respect to OM origin and maturity, lake water chemistry, and depositional conditions. Total organic carbon (TOC) varies from 0.25-6.49 wt.% and correlates with lithofacies in high-order cycles (HCs). TOC is extremely high in maximum-transgressive profundal shale. Maturity parameters, such as Ts/(Ts+Tm), dia-/regular- C29-steranes, and PWCPP+aa)-C29-steranes, suggest the OM is mainly immature with minority is slightly mature. Dominance of short-chain (C 12-C20), long-chain (C25-C35), and odd-carbon-numbered n-alkanes with a carbon preference index of 1.2-2.1, high carbon/nitrogen ratios of 28.7-63.3, and low terrigenous/aquatic ratios of 0.57 on average suggest that the all OM, regardless maturity, was derived from a mixture of higher terrigenous plants, aquatic algae, microorganisms, and macrophytes, resulting in types I and II kerogens. High ratios of diasteranes index, and C30-hopane/C29-regular steranes suggest a major contribution of land plant debris modified by microbial activities in a typical clay-rich source rocks deposited in acid conditions. Moderate pristane/phytane of 1.0-2.0, low gammacerane index, homohopane index, trace P-carotane and absence of 4-methylsteranes suggest dysoxic-hypoxic and fresh-brackish lake water.

TOC, C/N ratio, $\delta^{13}C$, and specific biomarker indices reflecting lakewater chemistry and biological communities vary systematically as lake expands and contracts, suggesting a solid correlation between litho- and organa-facies in the HCs. Three distinct organofacies have been identified and correlated with litho-facies within the meter-scale HCs. The cyclo-/chemo-stratigraphic model envisages the organa-facies of poor source rock quality in lake plain environments; of high total organic content in littoral environments; and of excellent oil-prone organic matter in profundal environments with a stratified water column. The lake plain organa-facies is dominated by siltstone and very fine sandstone, deposited during shoreline progradation, and characterized by poor-quality OM, with extremely low maturity, mainly stemmed from

higher terrigenous plants and partially from aquatic microorganisms, in shallow and oxic-fresh water. The lake littoral organofacies consists of dolomitic shale and dolomite deposited during lake contraction, and characterized by extremely high TOC, low/moderate OM maturity, with mixed contribution of aquatic algae, microorganism, and higher terrigenous plant debris highly modified by microbial activities, in fresh-brackish/alkaline lake water, shallow to deep littoral environments with open hydrology. The profundal organofacies is composed of black shale deposited during shoreline transgression, and distinguished by excellent oil-prone OM, with low/moderate maturity, derived from a major contribution of aquatic organisms (phytoplankton, dinoflagellates, green algae) mixed with minor input from macrophytes and higher plants, in acid-anoxic profundal environments with a salty-stratified water column.

A detailed cyclo- and chemo-stratigraphic framework and process-response depositional model of lacustrine deposits in this research may serve for studying sedimentology and stratigraphy of lacustrine deposits and assessing source rock richness, distribution, and oil-gas generation potential in other lacustrine rift basin. Particularly, this research will provide insights into the physical and chemical processes and their genetic relationships during deposition and diagenesis of lacustrine shales at a basin scale.