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Organic geochemistry and hydrocarbon potential contrasts among lithologically different source rocks in the Qingxi Sag, Jiuquan Basin, Northwest China

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Jiuquan Basin, located in the eastern part of Hexi Corridor, is a medium- to small-sized superimposed basin in northwest China. Situated in the southwest of the basin is the Qingxi sag, in which the development of large sets of argillaceous dolomite dominate (lithological assemblage named as LSA) and dolomitic mudstone (LSB), partially being mudstone. From electronical and seismic profile features, the Lower Cretaceous can be divided into the Chijinpu Formation, Xiagou Formation, and Zhonggou Formation in the Qingxi Sag. Moreover, the Xiagou Formation can be divided into four members, represented as K1g0, K1g1, K1g2, and K1g3. The given lithological assemblages and occurrence of particular mineralogical combinations indicate that it is the product of hydrothermal deposition. Lithologically, the argillaceous dolomite and dolomitic mudstone are diametrically different in both mineral contents and types. The integration of field outcrop observation and sampling with laboratory analyses, including solvent extract, Rock-Eval (S1, S2, and Tmax), organic petrography (lithological identification, cement, grain, mineral, and maceral observation), and laboratory modeling of hydrocarbon generation, show that both LSA and LSB contains good hydrocarbon potentials but rather different mineralogical compositions. The concurrence of LSA and LSB indicates the alternate interaction between the hydrothermal deposition and normal lacustrine deposits. The LSA mainly contains Type I kerogen and much lower Pr/Ph ratio, indicating parental material sourced from lacustrine algae and bacteria and much stronger reduction depostional environment. However, the LSB mainly contains Type III kerogen, containing parental material mainly sourced from terrestrial higher plant. And in the mudstone, there is almost no Type I kerogen, indicating no substantial input of lacustrine phytoplankton. The LSA contains TOC value of 1.2-3.2% (wt), averaging 2.1% (wt); while the LSB contains 0.8-2.4% (wt) with an average of 1.5% (wt). From geochemical testing results, both LSA and LSB contain high organic matter abundance with even higher organic matter abundance in the former. And it is suggested in the result of hydrocarbon generation modeling that the average liquid hydrocarbon yields of LSA and LSB are respectively 75kg/t TOC, 52kg/t TOC, both demonstrating good hydrocarbon potential. For the LSA and LSB samples, the GC-MS features are diametrically different: the distribution pattern for C27, C28, and C29 regular sterane in the LSA sample is “L”-shaped, indicating the parental material dominance of bacteria and lacustrine phytoplankton algae. And the asymmetry “V”-shaped distribution pattern for C27, C28, and C29 regular sterane in the LSB sample indicates that the dominance of terrestrial higher plant, which agrees with the analytical result of kerogen type. Therefore, LSA and LSB are the major source rocks in the Qingxi sag, with the mudstone being the secondary. In summary, the source rocks are controlled by the distribution of lithofacies; and the LSA was mainly deposited in the center of the sag and in the deep lake facies accompanied by the venting of volcanic thermal fluid, which favors the boom of lacustrine algae because of the enhancement of nutrients provided by volcanic material. The LSB was mainly in the outer periphery of the sag center and in the semi-deep lacustrine facies. From the analysis of oil-source correlation, the crude oils discovered in the Xiagou Formation show obvious stratabound features, namely they are self-generated and self-stored source-reservoir configuration relationship. The oils were mainly discovered in the K1g0, K1g1, and K1g2, which corresponds to the K1g0, K1g1, and K1g2 source rocks. It is of significance for the study of hydrocarbon potential for the thermally-deposited carbonate, thus providing experiences and practices for the future petroleum exploration in the domain of carbonate rocks.