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Wettability and its controlling factors of mixed shale oil reservoirs of Permian Lucaogou Formation, Jimsar Sag, southern Junggar Basin, NW China

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Wettability describes the tendency of a fluid phase to preferentially wet a rock. Due to diverse mineral composition and complex lithology, mixed shale oil reservoir wettability features and the associated controlling factors remain unclear, limiting the evaluation of oil-bearing property and sweet spot distribution. This paper examined mixed shale oil samples from the Jimusar Sag in the Lucaogou Formation. Casting thin sections, X-ray diffraction, geochemical characteristics, argon ion polishing scanning electron microscope, and high pressure mercury injection were used to analyzed lithologic characteristics, mineral compositions, and pore-throat structures within the mixed shale oil reservoir. Using spontaneous imbibition and nuclear magnetic resonance, the wettability characteristics were analyzed. Impacts of organic matter abundance, mineral composition, pore-throat structure, and source-reservoir combination on wettability were discussed. Lucaogou mixed shale oil reservoir primarily contains intergranular dissolved pores, intragranular dissolved pores, and intercrystalline pores. Three types of mercury intrusion cures were observed, including a weak platform shape (type I), gentle straight line shape (type II), and upward convex shape (type III), corresponding to intergranular, dissolved, and dissolved-intercrystalline dominant pore-throat systems, respectively. Mixed shale oil reservoirs show dual wet properties, containing both oil-wet and water-wet pores. Oil-wet pores (large pores with T2> 1 ms) are more common and have better connectivity than water-wet pores (small pores with T2< 1 ms) (Fig. 1). Dolomite-bearing siltstone and mudstone are primarily strongly oil wet, while siltstone is primarily mixed wet. Type II and type III pore-throat systems are more oil-wet than type I for the same source-reservoir combination. Mixed shale oil reservoir wettability is primarily controlled by three factors, including organic matter abundance, source-reservoir combination, and dolomite content (Fig. 2). The influence of pore-throat structure is weak. High organic matter abundance, an integrated source-reservoir or adjacent source-reservoir, and appropriate dolomite content are necessary conditions for forming a strong oil-wet shale oil reservoir in the Lucaogou Formation. Stronger oil wet is beneficial for shale oil charging and enrichment.