Enrichment of Tight oil in Yanchang Formation in Ordos Basin and Effective Development Technology

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Tight oil in Yanchang formation, late Triassic, formed in fairly deep lake to deep lake sedimentary facies, is a kind of tight sandstone oil. With typical cases of that in Chang7 oil-bearing layer and Chang6 oil-bearing layer (in central part of the basin), the tight oil is rich in resources. Besides that, main characteristics of the tight oil were summarized as follows, wide distribution area, tight formation, complex pore-throat structure, low porosity & permeability, high oil saturation, light density, and low pressure coefficient. The geological conditions for tight oil accumulation in Yanchang formation are superior. Two kinds of thick source rocks, black shale and dark mudstone, were extensively distributed in the area. The rapid subsidence of the basin, impacted by tectonic event happened during the period of late Chang 8, result to increasing of water depth and then diverse types of deep water sedimentation. Among them, dark mudstone and shale, deposited during early stage of Chang7 period, are the most important source rocks in mesozoic group. According to difference of organic laminae and petrology, Chang 7 source rocks are divided into two types, black shale and dark mudstone. In the middle and later periods of Chang 7, with withdrawal of lake and advancing of delta to the central part of the basin(with sediment provenance of both southwest and northeast), gravity flow deposition developed in the central part of the basin and the delta developed near the shoreline. In the basin, Chang 7 and Chang 6 oil-bearing layers are mainly tight reservoir and the sedimentary phase of them are mainly show two types, delta front and gravity flow deposition. The latter one can be subdivided into three types, sandy debris flow, turbidite, and slump deposit, according to genetic mechanism. These four types of sandbody, with different cause of formation and characters, corresponding to four sedimentary phases, are main reservoir rocks of tight oil. Among them, the ones formed with sedimentary phases of sandy debris flow and delta front are main types, because of large sandbody scale and relatively good reservoir property. In order to solve the problems that conventional reservoir testing methods with low precision, can not satisfy the requirement of finding extremely small scale pores and throats in tight oil reservoir, a series of new methods, such as FESEM, Micro-CT, QEMSCAN, etc. were applied, combined with conventional methods, for finely recognition of pores and throats in tight oil reservoir in multi-scale, from micro to nano scale. For classification of pores in tight oil reservoir in the basin, the classification scheme of pores in low permeability reservoir was referenced and the characteristics of pore scale and types in tight oil reservoir were also considered. The types of pore in tight oil reservoir in Ordos basin were finally divided into five types, large pores, middle pores, small pores, micro-pores and nano-pores. It can be seen from the research result that, throat radius of tight oil reservoir were mainly distributed from 25 to 250nm and the storage space of it is mainly composed of micro-scale pores and nano-scale throats. Because strong capillary pressure in pore-throat network of micro to nano scale limits function of buoyancy during oil accumulation, the migration pattern of oil in tight reservoir is mainly in short distance and vertical direction, then side direction. The organic matter abundance and hydrocarbon-generation amount of Chang7 source rocks were high enough to generate strong hydrocarbon-generating overpressure during transformation of organic matter to hydrocarbon. Physical simulation of oil accumulation in tight reservoir shows that oil was driven into tight reservoir under an unusual high pressure and the process can be obviously divided into two stages, fast accumulation stage and slow enrichment stage. The accumulation of oil were characterized by high pressure continuous filling, multiple stage displacement and near source migration and accumulation. Reservoir enrichment was controlled by both accumulation pressure and reservoir property. The "sweet spots" with thick layer, good reservoir property, abundance fractures & micro-fractures, high oil saturation,
abundant reserves, are main targets for tight oil exploration and development. Because of low pressure coefficient and weak natural energy, conventional stimulation in Yanchang tight reservoir can not result to high initial potential of production. A series of key technologies were researched and finally mastered, such as horizontal well development technology, cluster horizontal well completion technology, horizontal well domain stimulation technology. The rapid transfer from resources to reserves, production and finally benefits in turn were realized.