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Complex Interplays and Gas Generation Models in the Northeastern Sichuan Basin

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Basin evolution and hydrocarbon generation processes are complex in the Sichuan Basin, as this basin has experienced multiple tectonostratigraphic cycles and the Paleozoic marine strata in this basin is currently under high temperature and high pressure regimes. The co-occurrence of multiple petroleum source beds, multiple forms of organic molecules within any individual beds, as well as the variation in the chemistry and subsequent timing of hydrocarbon generation for these organic molecules, make the dynamic hydrocarbon generation processes in this basin display four distinctive characteristics, multiple sources, successive generation from different source material, multiple episodes of generation processes, and intermixing of hydrocarbon fluids of multiple origins.

There are several prolific Paleozoic marine source rocks in the Sichuan Basin. In addition to kerogens in these source rocks, organic material suitable for hydrocarbon (particularly gas) generation at high to over mature stages is highly diversified, including paleo-oil accumulations, dispersed organics in the carrier beds and inter- and intra-reservoirs beds, and organic salts in many carbonates. Successiveness and multi-episodes are two of the characteristics of the dynamic hydrocarbon processes: on one hand, thermal evolution of sedimentary organic matter is a continuous process, with hydrocarbon generation occurring primarily from kerogen in the early stage and liquid hydrocarbon becoming the main source for subsequent generation of light hydrocarbons and gaseous alkanes; one the other hand, a given source bed could experience multiple hydrocarbon generation processes under multicyclic tectonostratigraphic basin evolution, making secondary hydrocarbon generation a common phenomenon in many of the marine strata in southern and western China. Based on this fundamental understanding, we stress the important role of dispersed organic matter in sedimentary strata for the origin of the commercial gas accumulations in Sichuan. The hydrocarbon potential and evaluation criteria of dispersed organic matter are studied through a number of lab simulation experiments, and implications for the gas charging models of the Puguang gas field are considered in great detail.

In the consideration of the genetic complexity of the gas accumulation in northeastern Sichuan, one has to take into account of the complexity in the geological controls for the hydrocarbon generation processes under high temperature and high pressure regimes in deep

subsurface, and the complexity in the chemical reactions that lead to gas generation, for example, kerogen degradation, oil cracking , organic-inorganic interactions, addition of external hydrogen substrates and thermochemical sulfate reduction. The key processes that are responsible for the generation accumulation in the Puguang gas field include (1) oil cracking; (2) kerogen degradation, and (3) TSR reactions modifying the gas compositions. The fundamental chemical reactions involve (1) kerogen degradation, through hydrolysis and rearrangement reactions, to form hetero-atom containing maga liquid hydrocarbon intermediates, bitumens and asphaltenes (rich in carbixylix acids, ketones, aldehides, esters); (2) subsequent thermal reaction to form liquid oil, water and carbon dioxide, through dealkylation, dehydration and condensation reactions; (3) dispersed soluble organic matter undergoes misappropriation reactions, to generate gas and carbon residues. In fact, after the initial biogeochemical transformation, sedimentary organic matter always contain insoluble kerogen and soluble bitumen and their interchange, and thermal evolution tend to generate chemically more stable, structurally more rigid kerogens, smaller organic molecules (such as methane) and ultimately organic carbon residue that has little gas potential.