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Facies Architecture and Reservoir Quality of the Paleogene Subaqueous Trachytes and its Implication to Hydrocarbon Exploration in Liaohe Basin, NE China

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ABSTRACT

The Peleogene strata in Liaohe Basin are composed of abundant intermediate and mafic volcanic rocks. In the past decade, over ten million barrels of oil reserves have been discovered primarily in the Eocene subaqueous trachytes in the eastern part of Liaohe Basin, yet showing huge exploration potential in the volcanic intervals. Based on studies of approximately 1,100 meters long core samples from over 100 boreholes, it's assumed that the oil bearing trachytes were dominantly erupted and emplaced in subaqueous settings. Borehole data and seismic profiles were used to study the facies architecture and reservoir quality of these trachytic rocks, and to reveal the distribution of high-quality reservoirs and their controlling factors. Five principal volcanic facies and eleven sub-facies were identified in the trachytic successions by means of facies analysis on both boreholes and cross-sections, dominated by extursive facies with 51.6% and explosive facies with 25.8% in thickness, while the rest 22.6% were composed of volcanic conduit, effusive and volcaniclastic facies. A representative facies model was proposed for further volcanic facies analysis and prediction, comprising three volcanic facies associations corresponded to the proximity to volcanic conduit. Respectively, the central- proximal facies association is dominated by extrusive lava rocks, while the medial facies association is characterized by pyroclastic flow deposits, and the distal facies association is composed of water-settled fall deposits and volcaniclastic deposits. Lateral facies sequence from volcanic center to edge is as follows, the volcanic conduit and extrusive facies combination, the effusive and explosive facies combination, and the volcaniclastic facies. It is demonstrated by 280 core plug samples that the helium (He) porosity ranges from 0.4% to 28.9% (average 9.4%) and the gas permeability ranges between 0.02 and 12.60 md (geomean 0.20 md). Quenching fragmentation and volcanic explosion resulted by mingling of magma and water are considered to be the key factors to the characteristics of volcanic facies and reservoir qualities of subaqueous trachytes in the study area. Base on resin-impregnated thin section and scanning electron microscope analysis, the intra-particle dissolution pores, residual inter-particle pores and the related inter-particle cement dissolution pores are proved to be the most important valid porosities in trachytic reservoirs, especially, the intra-particle phenocrystal and matrix dissolution pores make the major contribution to reserve capacities. Three principal high-quality reservoirs are developed in outer extrusive sub-facies, pyroclastic flow sub-facies and volcanic diatreme sub-facies, which should be taken as the major exploration targets of the subaqueous trachytic successions.