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Research paper

Diagenetic history and reservoir quality of tight sandstones: A case study from Shiqianfeng sandstones in upper Permian of Dongpu Depression, Bohai Bay Basin, eastern China

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ABSTRACT

The upper Permian Shiqianfeng sandstones, located in the Dongpu Depression, Bohai Bay Basin, China, are fluvio-lacustrine deposits and have high content of pore-filling volcanic dust (average 7.93 vol %). This study focuses on diagenetic processes and reservoir quality of the tight sandstones based on different lithofacies. An integrated approach, such as core observation, X-ray diffraction, scanning electron microscopy, cathode luminescence, stable isotope analysis of carbon and oxygen compositions, electron microprobe analysis and fluid inclusion analysis, were utilized. The tight sandstones consist of subarkose and lithic subarkose, and have undergone significant diagenetic events, including compaction, quartz cementation, carbonate cementation (mainly calcite and ferrocalcite) and formation of authigenic clay minerals (i.e., chlorite rims, kaolinite and mixed-layer illite/smectite). The volcanic dust altered with increase of burial depth, resulting in the production of abundant silicic materials and depletion of metallic ions (i.e., Fe^{2+}, Mg^{2+}, Ca^{2+} and Mn^{2+}). This process formed subhedral micro-quartz, pore-filling authigenic quartz, smectite and chlorite rims during the early diagenetic stage. Early-phase carbonate cements (calcite/ferrocalcite) occurred in several samples. They were also influenced by volcanic dust alteration, resulting in intrusive of Fe^{2+} and high contents of Mn^{2+} (average 12.5 mol %).

Further alteration of volcanic dust at the mesogenetic stage can result in cementation of kaolinite and euhedral micro-quartz. Quartz overgrowth developed because of smectite-to-illite reactions and the alteration of volcanic dust. Late-phase carbonate cements (dolomite and ankerite) are rare. The present low porosity (average 6.17 vol %) and permeability (average 0.198 mD) of the Shiqianfeng sandstones mainly resulted from intense compaction, diverse cementation and pore-filling of volcanic dust. As strong hydrodynamic conditions of pore water, modification of reservoir quality in the conglomeratic sandstone and gritstone lithofacies (mainly distribute in braided channel) occurred by alteration of volcanic dust. Thick braided channel at the high structural position should be the focal point for the future exploration.

1. Introduction

Deeply buried tight sandstones are widely distributed in Chinese petroliferous basins, and the research mainly focused on reservoir densification, microscopic pore structures and oil/gas accumulation (Guo et al., 2016; Xi et al., 2015a; Zhou et al., 2016). They are generally characterized by deep burial, intense diagenetic processes and low porosity & permeability (Zhang, 2009; Xi et al., 2015a; Yuan et al., 2015). The reservoir quality of tight sandstones is mainly controlled by detrital composition, depositional environment, sedimentary facies, burial temperatures, strata pressures, and the chemical composition and flowrate of the pore water

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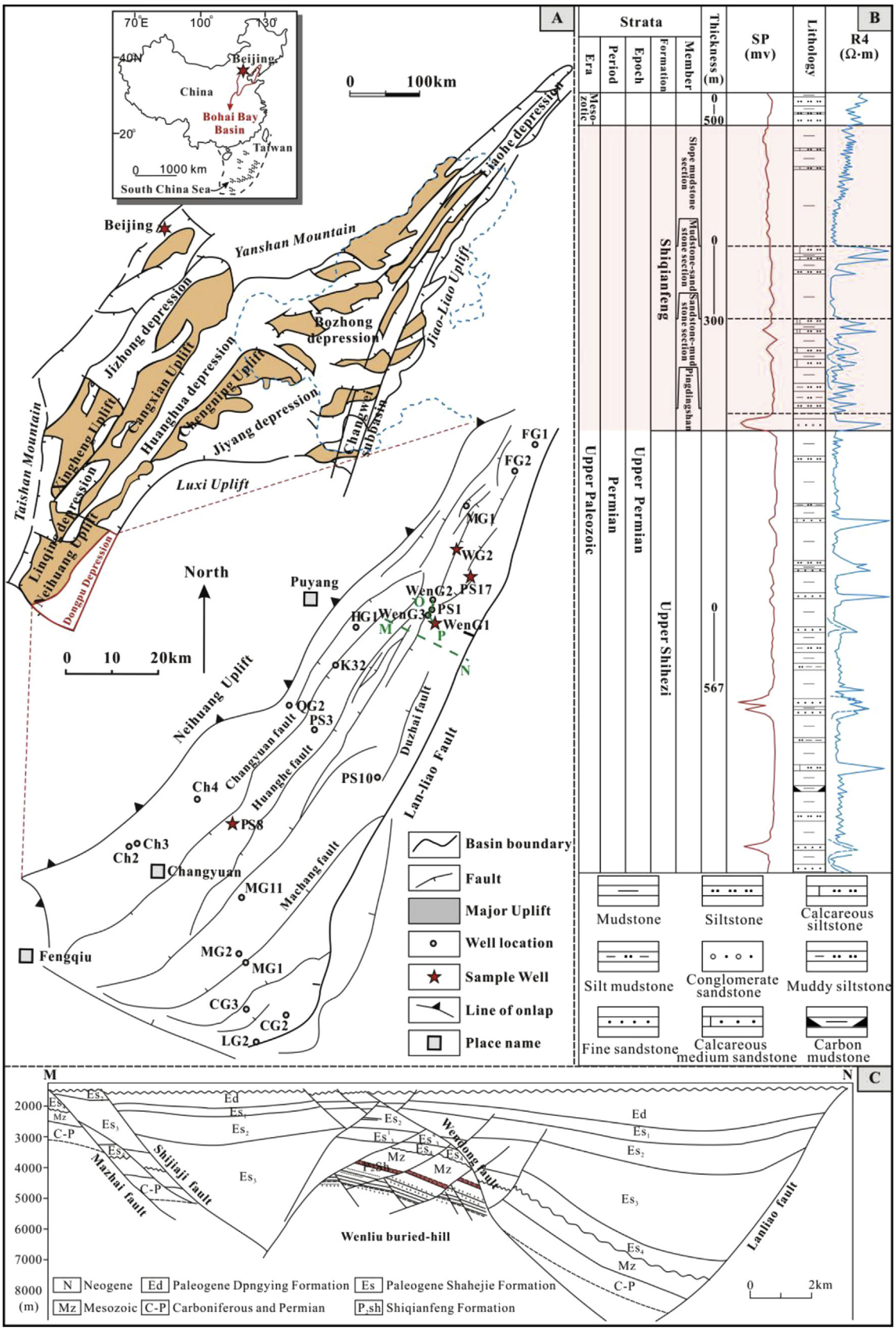

Fig. 1. Structural zone of the Dongpu Depression. (A) Location map of the Dongpu Depression; (B) schematic stratigraphy of the Dongpu Depression; (C) various tectonic structural zones and key stratigraphic intervals within the Dongpu Depression.