

Upper Paleozoic petroleum system, Ordos Basin, China

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Abstract

The Ordos Basin is a typical lapped basin, including three sequences of strata: early Paleozoic, late Paleozoic and Mesozoic, with a total thickness of 4000–6000 m. Impermeable sealing beds are well developed at the top and base of the upper Paleozoic sequence, separating it from the Mesozoic and the lower Paleozoic strata to form an independent petroleum system. In this petroleum system, the source rocks are widely distributed coals and dark mudstones occurring in the Carboniferous–lower Permian coal measures, with a thickness of 10–15 and 40–60 m, respectively. The reservoirs are mainly early Permian tight sandstones, mostly with a porosity of 4–8% and a permeability of $0.1\text{--}1.0 \times 10^{-3} \mu\text{m}^2$. The regional cap rock is a 100–150 m thick mudstone in the upper Permian strata. The structural framework of the basin is a huge asymmetric syncline, dipping gently toward the east and north, and steeply toward the south and west. Well data show that gas-saturated, gas–water transition and water-saturated zones are developed from the depositional center to the basin edges. The gas-saturated zone mainly lies in the gently dipping slope area of the Shanbei Slope. Toward eastern and northern up-dip directions the water–gas transitional zone occurs, and finally the water-saturated zone, presenting a reverse relation of water on top of gas. An abnormal negative strata pressure is developed in the gas-bearing area, with a pressure coefficient (C_p) ranging from 0.83 to 0.95. Fluid inclusion data indicate that the upper Paleozoic gas pool began to develop around the Wuqi area at about 150 Ma, and it extended toward the north and was largely formed at about 120 Ma, showing there was a regional migration of the gas–water interface from south to north during the gas pool formation. These characteristics appear to show that the northern and eastern margins of the petroleum system are defined by a regional hydrodynamic regime. The critical moment of the petroleum system occurred during the early Cretaceous. The basin experienced a rapid subsidence and a significant geothermal event, resulting in the source rocks being matured into the main stage of gas generation to form a huge amount of gas. The gas migrated into the tight sandstone reservoirs and displaced the rock pore water to form the gas pools and developing the regional hydrodynamic trap.

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1. Introduction

The Ordos Basin is located in the middle of mainland China, covering an area of $25 \times 10^4 \text{ km}^2$ (Figs. 1 and 2) and containing sediments with a total thickness of 4000–6000 m. It is a typical lapped basin, including lower Paleozoic, upper Paleozoic and Mesozoic sequences of strata with quite different characteristics (Fig. 3). The lower Paleozoic strata are dominated by carbonates with a thickness of

1000–2000 m. Whereas the Carboniferous–Permian strata are coal measures with a thickness of 800–1200 m, the Mesozoic strata consist of fluvial lacustrine sequences, with a thickness of 2200–2800 m (CPGEC, 1992). Throughout most of the basin, the upper Cretaceous and Cenozoic sediments are absent because of uplift and erosion of the basin after the late Cretaceous (Fig. 2; CPGEC, 1992).

The basin has had a history of some forty years of exploration and geological research (CPGEC, 1992; Wang, 1996). For quite a long period the main exploration objectives were in the Mesozoic and lower Paleozoic sediments (Shu, 1994; Yang and Pei, 1996; CPGEC, 1992; Zhen and Huan, 1998), therefore, less attention was paid to the upper Paleozoic strata. It is now clear that the lower Paleozoic and Mesozoic strata have gas and oil potential, respectively. Areas of high

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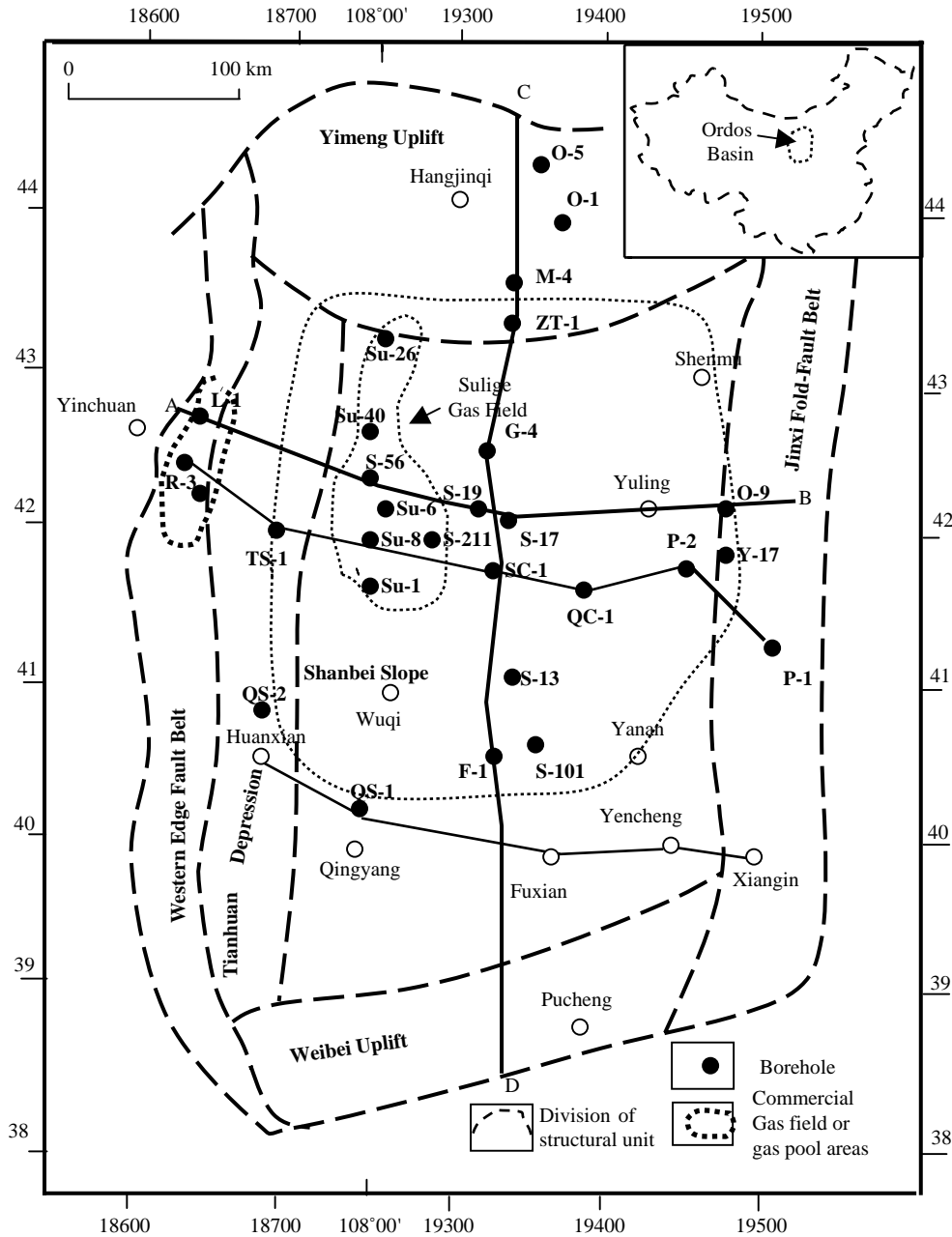


Fig. 1. Sketch map showing structural framework and locations of upper Paleozoic gas pools of the Ordos Basin. The main boreholes are marked and four sections are located.

potential in the lower Paleozoic strata are paleo-uplifts and unconformity surfaces between lower Carboniferous and Ordovician, located in the middle of the basin, such as the Middle Gas Field (CPGEC, 1992; Yang and Pei, 1996; Dai et al., 1997), whereas the Mesozoic strata in the southern part of the basin contain more than 95% of the total oil resources of the basin (CPGEC, 1992). In recent years, a large gas pool termed the Sulige Gas Pool has been found in upper Paleozoic strata (He et al., 2003), which has led to great interest in these rocks. Some recent work has involved investigation of the structural characteristics, source rock distribution, gas origins,

reservoir-cap rock combinations and trap formation (Wei et al., 2003). It was recognised that impermeable beds developed widely at the top and base of the upper Paleozoic strata, and lack of large scale of vertical faulting in the basin resulted in the isolation of the upper Paleozoic strata from lower Paleozoic and Mesozoic strata and the formation of an independent petroleum system (Wei et al., 2003). However, there have not been reports or publications discussing the formation of the petroleum system. The purpose of this paper is to present the characteristics and origin of this petroleum system using an integrated geological and geochemical

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