



Gas and water distribution of Ordovician Majiagou Formation in northwest of Ordos Basin, NW China



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Abstract: Based on the geologic background and reservoir characteristics, the characteristics and controlling factors of gas and water distribution of the carbonate reservoir in the 5th member of Ordovician Majiagou Formation in Northwest Ordos Basin have been examined from macro and micro aspects using data of structure, deposition, diagenesis, paleotopography, physical property, mercury injection, well logs and core observation. The 5th member of Majiagou Formation in the study area shows very complex gas and water distribution pattern: the gas layer is distributed uniformly across the whole area in 2D horizontal map, while the water layer is scattered and concentrates in small area, appearing in discontinuous distribution; there is no gas and water interbeds in vertical direction, making it difficult to develop the gas reservoir efficiently. The gas and water distribution is controlled by paleogeomorphology and diagenesis macroscopically, and is controlled by pore-throat structure, connectivity and the transportation relation between source rock and reservoir microscopically. The gas largely concentrates in and around the ancient grooves and low hill regions in the paleokast slope where the reservoirs have good physical properties and good pore - throat connectivity, and there is no bauxite between source rock and reservoir, making it easy for gas to charge and accumulate.

Key words: carbonate gas reservoir; gas and water distribution; paleogeomorphology; diagenesis; pore structure; transportation relation; Ordos Basin; Ordovician Majiagou Formation

1. Geological background of the study area

During the depositional stage of Ordovician Majiagou Formation, a large-scale regression happened in the northwestern Ordos Basin with water salinized, the main depositional environment there turned into evaporative tidal flat with developed supratidal and intertidal zones, including five kinds of micro-sedimentary facies, clay dolomitic flat, dolomitic flat, gypsum dolomitic flat, limestone dolomitic flat and limestone flat^[1-4]. The dolomite reservoir which developed in the 5th member of Ordovician Majiagou Formation is the major gas reservoir in the Lower Paleozoic. In the late Ordovician, the Caledonian Orogeny caused crustal uplifting, so the top of the 5th member of Ordovician Majiagou Formation exposed and suffered weathering, leading to the development of weathering crust reservoir with strong heterogeneity. Also, due to multi karstification processes after gas accumulation, the distribution of gas and water in the carbonate reservoir in the area is very complicated, and there is no edge water and bottom water in carbonate reservoir, and the obvious boundary of gas and wa-

ter is not easily identified. The study area is located in the north part of Jingbian gas field (Fig. 1) in the northwest of Ordos Basin, with an area of about 14 000 km². Jingbian gas field is one of the main gas fields in the Ordos Basin, the largest gas field of China in the Lower Paleozoic. The study area is an extension of Jingbian gas field, where the unclear distribution of gas and water has restricted the exploration, leading to lower natural gas production. In this study, the characteristics of gas and water distribution in the horizontal and vertical section have been analyzed by using gas testing data available; macro and micro controlling factors of gas and water distribution in the carbonate rock reservoirs have been figured out by combining rock physics experiment and logging interpretation results and analyzing macro geological factors including structure, depositional environment, paleogeomorphology and diagenesis, and micro reservoir characteristics including the physical properties, pore structure and natural gas geochemical indexes; and finally, the gas rich area has been predicted with this method.

Received date: 08 Nov. 2015; **Revised date:** 28 Mar. 2016.

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Foundation item: Supported by the National Natural Science Foundation of China (41172122).

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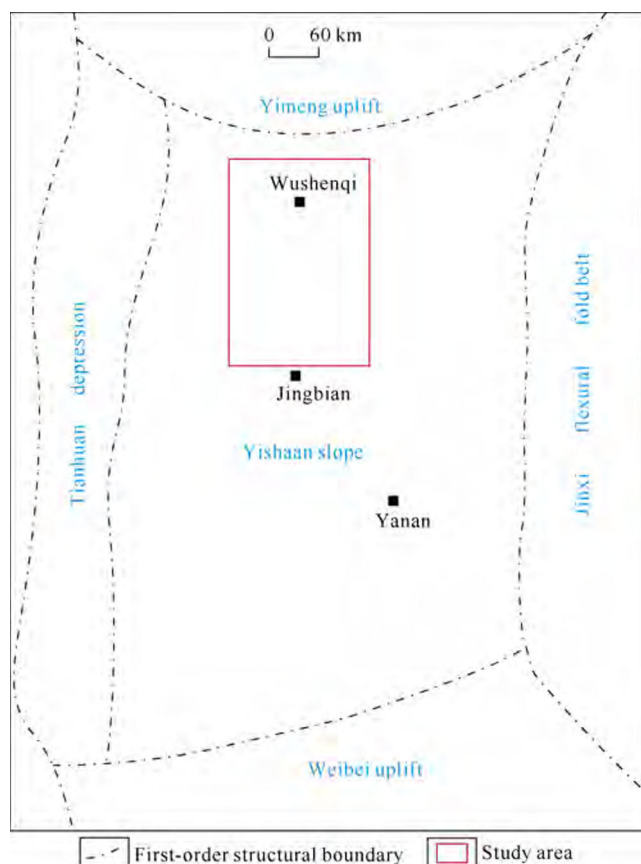


Fig. 1. Location of the study area.

2. Gas water distribution characteristics

Comprised of approximately 40 meters thick dolomite, the 5th member of the Ordovician Majiagou Formation in the northwest of Ordos Basin is divided into three gas layer groups, namely the upper, middle and lower gas layer groups. Gas testing results show that the 5th member of Ordovician Majiagou Formation has high water production. Statistics show that 77% of the 423 gas testing wells are gas producing wells, while 9% are water and gas producing wells, and 14% are water producing wells, in other words, 23% of the wells produce formation water.

2.1 The 2-D horizontal map characteristics of gas-water distribution

According to the 2-D horizontal map of the gas producing wells, gas-water producing wells and water producing wells in the 5th member of Ordovician Majiagou Formation (Fig. 2), it can be seen that water producing wells are mainly distributed in the midwestern region of study area. Gas producing wells are mostly in the central and eastern regions. Besides, the water production areas are scattered and concentrated in small areas with discontinuous distribution. Gas-water producing wells on the other hand are distributed erratically and not usually in proximity to the water producing wells.

2.2. Characteristics of gas-water vertical distribution

Comprehensive analysis of gas testing results shows the vertical gas and water distribution in the 5th member of Ordovician

Majiagou Formation of the study area has one obvious feature: the three gas groups often show a succession of gas zone/gas zone/gas zone or water zone/water zone/water zone, coexistence of gas zone and water zone in the same well is rare. Based on the results of gas testing, the testing zones in one single well all produce gas or water in most of the wells. Therefore, there are few wells producing gas and water at the same time in the 5th member of Ordovician Majiagou Formation, in other words, edge water and bottom water don't exist in the study area.

3. Macro control factors of gas-water distribution

3.1. Relationship between tectonism and gas-water distribution

The Ordos Basin is a huge gentle slope, inclining west with a dip angle of less than 1° ^[5-6]. Located in the northwest of Yishaan slope of Ordos Basin, the study area is inclining southwest, lowest in the southwest and highest in the northeast, with a dip angle of 0.23° in the main part (Fig. 2). It can be seen that gas wells are mainly concentrated on the structural high, which indicates that structural relief controls water-gas differentiation to some extent in the study area; while since water and gas-water producing wells not only occur in the southwest (structural low) but also in the central and northeast of the area, structure is not the main factor controlling the distribution of gas and water there.

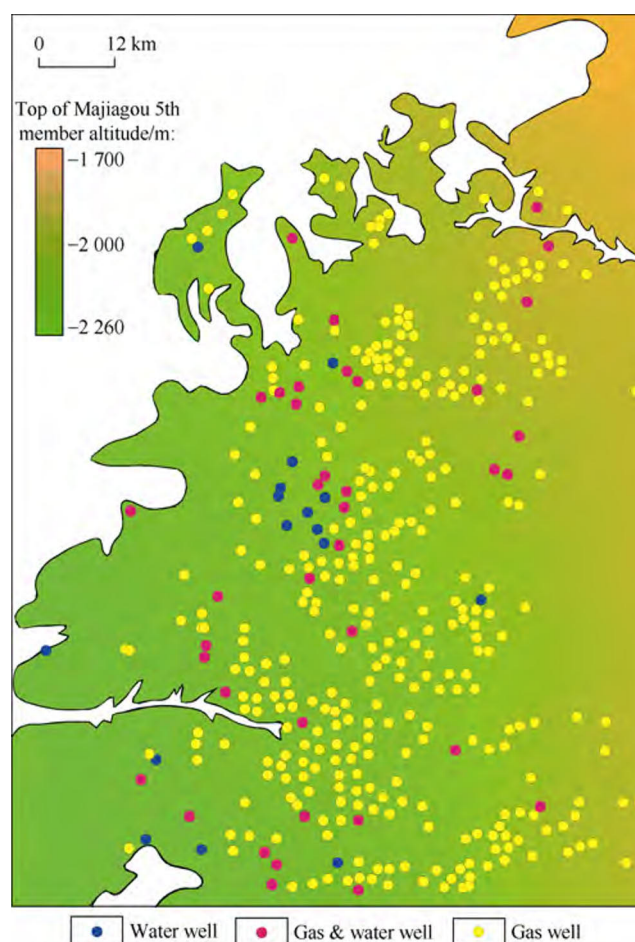


Fig. 2. Planar map of gas-water distribution.

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