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Original research paper

Reservoir characteristics and control factors of Carboniferous volcanic gas reservoirs in the Dixi area of Junggar Basin, China

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Abstract

Field outcrop observation, drilling core description, thin-section analysis, SEM analysis, and geochemistry, indicate that Dixi area of Carboniferous volcanic rock gas reservoir belongs to the volcanic rock oil reservoir of the authigenic gas reservoir. The source rocks make contact with volcanic rock reservoir directly or by fault, and having the characteristics of near source accumulation. The volcanic rock reservoir rocks mainly consist of acidic rhyolite and dacite, intermediate andesite, basic basalt and volcanic breccia: (1) Acidic rhyolite and dacite reservoirs are developed in the middle-lower part of the structure, have suffered strong denudation effect, and the secondary pores have formed in the weathering and tectonic burial stages, but primary pores are not developed within the early diagenesis stage. Average porosity is only at 8%, and the maximum porosity is at 13.5%, with oil and gas accumulation showing poor performance. (2) Intermediate andesite and basic basalt reservoirs are mainly distributed near the crater, which resembles the size of and suggests a volcanic eruption. Primary pores are formed in the early diagenetic stage, secondary pores developed in weathering and erosion transformation stage, and secondary fractures formed in the tectonic burial stage. The average porosity is at 9.2%, and the maximum porosity is at 21.9%: it is of the high-quality reservoir types in Dixi area. (3) The volcanic breccia reservoir has the same diagenetic features with sedimentary rocks, but also has the same mineral composition with volcanic rock; rigid components can keep the primary porosity without being affected by compaction during the burial process. At the same time, the brittleness of volcanic breccia reservoir makes it easily fracture under the stress; internal fracture was developmental. Volcanic breccia developed in the structural high part and suffered a long-term leaching effect. The original pore-fracture combination also made volcanic breccia reservoir more easily leached by fresh water or groundwater, leading to secondary erosion pores. Volcanic rock weathering obviously has control on reservoir properties, and while the thickness of the weathering crust is 200−300 m, the properties of volcanic rock reservoir are the best. This is attributed mainly to the period during and after the volcano eruption, in which tectonism made the brittle volcanic rock develop a large number of fractures and micro cracks. This has led to the increased permeability of volcanic rock reservoir, the weathering and leaching effect of volcanic rock diagenetic late phase (which also formed lots of secondary pores), and greatly improved reservoir conditions. The overlying Permian Wutonggou formation mudstone provided high-quality cap rock for oil and gas accumulation.

Keywords: Carboniferous; Volcanic rock; Oil and gas accumulation; Junggar Basin

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1. Introduction

In the field of sedimentary petrology, diagenesis refers to a variety of physical, chemical and biological process which occurs to sediment before its metamorphism and after its deposition. [1,2]; this is distinguished clearly, and is not to be confused with the diagenesis of volcanic rock [3]. Many experts have made a deep study on the diagenesis of volcanic rocks [4−8], and have divided it into early and late diagenesis two stages. There are significant differences in different diagenetic stages of volcanic rock. Early diagenesis mainly refers to condensation and compaction of volcanic rock; late diagenesis refers to the process after consolidation, characterized and influenced by weathering and leaching, along with hydrothermal and burial effect, in which volcanic rock experiences mechanical and chemical compaction, dissolution and metasomatism [9]

In recent years, the oil and gas exploration of Carboniferous volcanic rocks in the Ludong area of Junggar Basin continues to get breakthroughs, and the discovered Dixi gas reservoir have been found to exceed 100 billion cubic meters. The Dixi gas reservoir in eastern of Junggar Basin is consists of Well Dixi 17 area, Well Dixi 14 area, Well Dixi 18 area and Well Dixi 10 area—four gas reservoirs from west to east (Fig. 1). For the Carboniferous volcanic rocks in Ludong area, palaeovolcanic rock body style and assemblage features were diverse [10], most of it developing into weathering crust-type volcanic rock oil gas reservoir [11−14]. A lot of research work has been done on the lithofacies distribution [15], space type [16,17], formation stage [18,19], and the main factor which controls the properties [20−23] of volcanic reservoir, on weathering and leaching [24] after cold solidifying volcanic rock effects, and on how the dissolution of the mineral particles in the volcanic rocks during burial and the tectonic fracture effectively aid in the performance of accumulation of the volcanic rock reservoir [25]. However, there is a little study on the evolution of volcanic rock reservoir and the development mode of oil and gas accumulation. This paper will take Carboniferous volcanic rock core samples as the foundation, through observation of the specimen and analysis of thin section identification and geochemical data. This is to preliminarily determine the volcanic rock reservoir pore evolution process in different stages, along with the main control factors of volcanic rock gas reservoirs, which would establish the accumulation model of Dixi area volcanic rock reservoir and provide the necessary basis for planning the Junggar Basin in Dixi area of Carboniferous volcanic reservoir.

2. Characteristics of volcanic reservoir in the Dixi area

The main types of Carboniferous volcanic reservoirs in the Dixi area are basically identified through the drilling core description, thin-section analysis, and SEM analysis. These are: (i) Basalt: Often a thick layer massive structure, developed with micro cracks and original pores, as well as with intergranular and dissolved pores. (ii) Andesite: Thick and massive structure, with more developed pores, dissolved pores, and micro-cracks. (iii) Rhyolite: Structure is rhyolitic and massive, one which pores are not developed, with the exception of dissolution pores and micro cracks. (iv) Volcanic breccia:

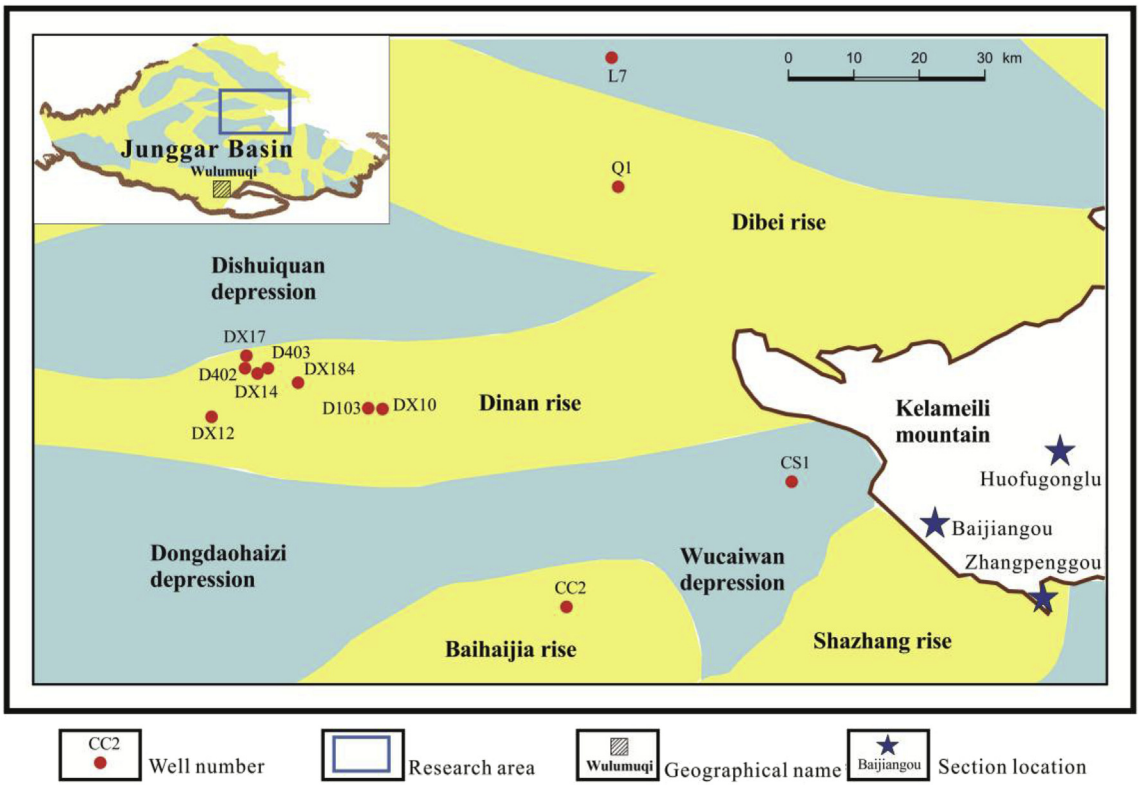

Fig. 1. The location of Dixi area.

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