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# Study on Reservoir Characteristics of Mesozoic Volcanic Buried Hill of KL16-1 Structure Belt in Laizhou Bay Sag

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## Abstract

**The Mesozoic buried hill of KL16-1 structural belt in Laizhou Bay Sag is an important oil and gas exploration area in Laizhou Bay sag, which has a good exploration prospect. Influenced by tectonic evolution, the types and main controlling factors of Mesozoic volcanic reservoirs are not clear, which affect the exploration and development of buried hill reservoirs. In this study, the lithologic characteristics, reservoir space types and the main controlling factors of volcanic reservoir development were systematically studied by casting thin sections, core data, well logging data and analytical laboratory data. The reservoirs in the study area are mainly volcanic clastic reservoirs, and the reservoir space types are mainly primary and secondary, and the primary reservoir space is mainly secondary. Comprehensive analysis shows that the main controlling factors of reservoir development are volcanic rock lithology, tectonic movement and diagenesis. The research results of this paper have certain significance for the fine study of the Mesozoic volcanic buried hill reservoir and the prediction of oil and gas reservoirs in the KL16-1 structural belt of Laizhou Bay Sag.**

## Keywords

**Laizhou Bay Sag; Mesozoic; Volcanic Reservoir; Reservoir Characteristics; Controlling Factors.**

## 1. Introduction

Multiple countries and regions have achieved certain results and understandings in the exploration and volcanic rock gas exploration research in oil and gas reservoirs of buried hill. In recent years, China has also submitted sub-mountain oil and gas exploration and volcanic rock oil exploration as a key exploration. With the rehearsal and in-depth research of volcanic rock oil accumulation conditions, experts and scholars believe that volcanic rock oil exploration is a new exploration area, which can provide guarantees for social economic development and national energy security (Wang et al, 2021). Therefore, through the study of volcanic reservoir characteristics, the main controlling factors of reservoirs are analyzed, and the volcanic rock oil exploration is important. This paper takes the Mesozoic volcanic buried hill reservoir of KL16-1 structural belt in Laizhou Bay Sag as the research object. Through the casting sheet, the core data, logging materials, analyte data, etc., the system is studied, and the rocky characteristics of the volcanic rock reservoir are studied. The spatial type, the main controlling factor of the development of reservoirs, the development of the exploration industry in the Laizhou Bay Sag, the exploration industry, the exploration industry, the exploration industry, has a certain significance and reference value.

## 2. Geologic setting

The study area is located in the KL16-1 structural belt of the Laizhou Bay Sag. The Laizhou Bay Sag is located in the southern Bohai Sea (Figure 1), with an area of about 1780 square kilometers. It is a Cenozoic faulted basin developed on the Mesozoic basement. Geological tectonic movement It is

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more frequent. It is adjacent to Ludong Uplift in the east, Kendong Uplift in the west, Weibei Sag in the south, Laibei Low Uplift in the north, Huanghekou Sag in the northwest, and Miaoxi Sag in the northeast, and Qingdong Sag in the southwest(Sun et al,2007;Yu et al,2008;Xu,2018)The Laizhou Bay Sag is a typical faulted lake basin with "North Fault and South Super". The main boundary faults of the basin are developed on the east, west and north sides of the basin, which makes the basin structure in different directions have more significant differences(Niu,2012). According to the structural evolution characteristics of the Bohai Bay Basin and the geographical location and structural position of the Laizhou Bay Sag, the structural evolution stages of the Laizhou Bay Sag can be divided into the first rifting episode, the second rifting episode, post-rifting heat subsidence and neotectonic movement on the whole.

The proven sedimentary strata in the Laizhou Bay Sag mainly include the Mesozoic, Kongdian Formation, Shahejie Formation, Dongying Formation of the Paleogene, Guantao Formation, Minghuazhen Formation of the Neogene and Quaternary Plain Formation. According to actual drilling data, the Mesozoic strata are mainly composed of volcanic breccia, tuff and other volcanic clastic rocks, as well as other lithologies such as dacite.

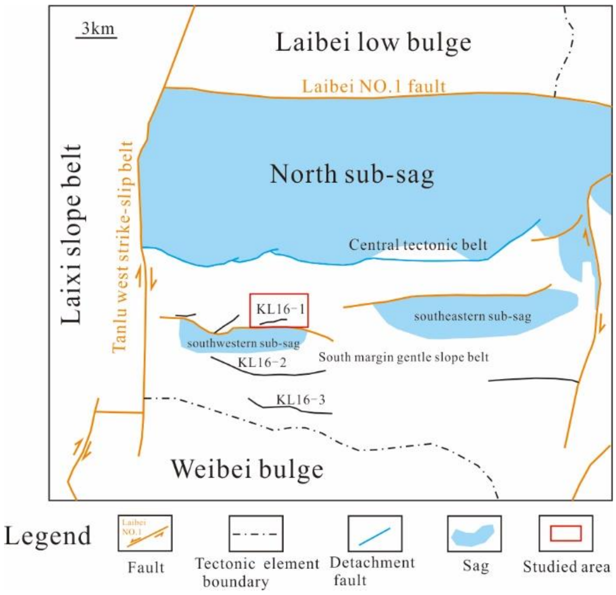


Figure 1. Tectonic unit map of the Laizhou Bay Sag.
Modified after Xu et al. (2018).

## 3. Petrological characteristics

Pyroclastic rocks are rocks formed by compaction and consolidation of various pyroclastic deposits due to volcanism (Liu et al,2018). There are many types of reservoirs in the Paleogene and Mesozoic buried hills of the KL16-1 structure in the Laizhou Bay Sag. The Mesozoic volcanic reservoirs studied in this study are mainly volcanic clastic reservoirs.

Pyroclastic rock is usually composed of tuff, tuffaceous volcanic breccia, tuffaceous glutenite, dacite and other lithologies. It uses air or water as a carrier to transport the original pyroclastic materials produced by volcanic eruptions. Rocks formed by accumulation and consolidation. The pyroclastic rock with a particle size of 2mm-50mm, which accounts for at least not less than 1/3 of the volume of the rock, is called volcanic breccia. The volcanic breccia grains have a breccia structure, generally Edges or sub-edges are formed by cementing smaller pyroclastic materials such as cuttings and crystals, which are poorly sorted (Figure 2a). The main composition of volcanic breccia in the study area is volcanic breccia and tuffaceous matter, of which volcanic breccia accounts for the majority, about 65%-75%, and the other parts are mainly tuffaceous.

Tuff with a tuff structure is one of the most widely distributed fine-grained volcanic clastic rocks in the study area. Volcanic ash and water chemicals usually cement the tuff (Figure 2b), and generally have poor bedding. Daxite is an acidic extrudate rock with a porphyritic structure. Its main minerals are plagioclase, quartz, pyroxene or hornblende, all of which can appear as phenocrysts in a fine-grained or vitreous matrix (Figure 2c).

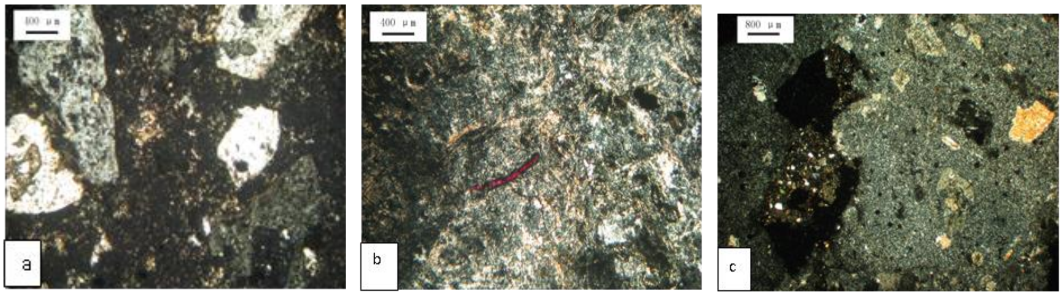


Figure 2. Petrology characteristics about buried hill volcanic rock reservoir of KL16-1 structural belt

(a) Well KL16-1-1, 1600.94m Tuffaceous, Volcanic Breccia; (b) Well KL16-1-4, 1603.0m, Tuff; (c) Well KL16-1-6, 1555.0m, Dacite

## 4. Reservoir performance

### 4.1 Reservoir physical property

Through collating 12 measured core data of Mesozoic volcanic rocks in the buried-hill zone of the study area, it is found that nearly half of the porosity is in the ultra-high porosity range. Therefore, the porosity of the Mesozoic volcanic rock reservoir is obviously superior. In terms of permeability, more than half of the cores are in the low permeability range of 0.1 to 1mD. For example, well KL16-1-1, the average measured porosity is 24.31%, the average logging porosity is 12.35%, and the average logging permeability is 1.75mD, indicating that it is a low porosity and extremely low permeability reservoir. On the whole, there are only a few high permeability and ultra-high permeability reservoirs in Mesozoic volcanic buried hills, and most of them belong to low permeability reservoirs, which are characterized by high porosity and low permeability.

### 4.2 Type of reservoir space

Due to the special mechanism of volcanism and the formation of volcanic rocks, the storage performance of volcanic rock reservoirs also has special properties. According to its formation mechanism, the storage space of volcanic rock reservoirs can be divided into two types: primary storage space and secondary storage space (Zhao et al, 1999; Liu,2012).

#### 3.2.1 Primary reservoir space

The primary reservoir space in the study area mainly includes intercrystalline pores, stomata, shrinkage joints, etc. Among them, the shape of the pores are mainly round, elongated, elliptical and irregular shapes, etc. The pore diameter is generally in the range of 0.03-0.5mm, which is generally due to the evaporation of the easily volatile components in the magma. Hole. Stomatal holes are mainly found in andesite, andesitic volcanic breccia, and basalt. The pores in volcanic rocks are usually easily filled with minerals such as chlorite and calcite (Figure 3a).

Mineral intercrystalline pores usually appear between feldspar crystals and feldspar crystals, between feldspar crystals and quartz crystals, and between biotite and hornblende and other mineral crystals. They are pores between mineral crystals.

Diagenetic shrinkage fractures are in the process of magma cooling. Because the internal temperature of the rock mass is different from the external temperature, the external condensing rate is faster than the internal, resulting in a temperature difference. There is a difference in stress between the internal and external rocks, which are formed when the magma condenses of. The contraction joint is irregular in shape, like mud cracks, wide in the middle and narrow on both sides, and terminates in the matrix.

### 3.2.2 Secondary reservoir space

The Mesozoic volcanic rock reservoirs in the study area include various secondary dissolution pores and fractures, structural fractures, and weathered fractures.

Tectonic cracks are cracks formed by the action of tectonic stress, and are usually related to regional tectonic stress. Tectonic fractures are ubiquitous in volcanic rocks. Due to tectonic action, pores in the reservoir are often cut through. Tectonic fractures have the function of enhancing the connectivity of the reservoir and increasing the permeability of volcanic rocks, and are good storage spaces in volcanic rocks. The crack surface is smooth, straight and extensible (Figure 3b).

Dissolution pores are formed by structural crevices and some post-altered, easily soluble rocks or minerals which are enlarged by later dissolution, mainly including intergranular dissolved pores, intragranular dissolved pores, intracrystalline dissolved pores and so on. Its formation is related to the direct erosion and seepage of surface water and formation water. The dissolution pores of volcanic buried hills in this area are mainly matrix dissolution pores and phenocryst dissolution pores in tuff and andesitic volcanic breccia, with a size of about 0.06 mm and poor connectivity (Figure 3c).

Dissolution fractures are common in volcanic breccia, tuff and andesite in this area. The fracture width is less than 0.1mm and the length is 1-3mm. It is unfilled or filled with siliceous and calcite, and the overall connectivity is poor.

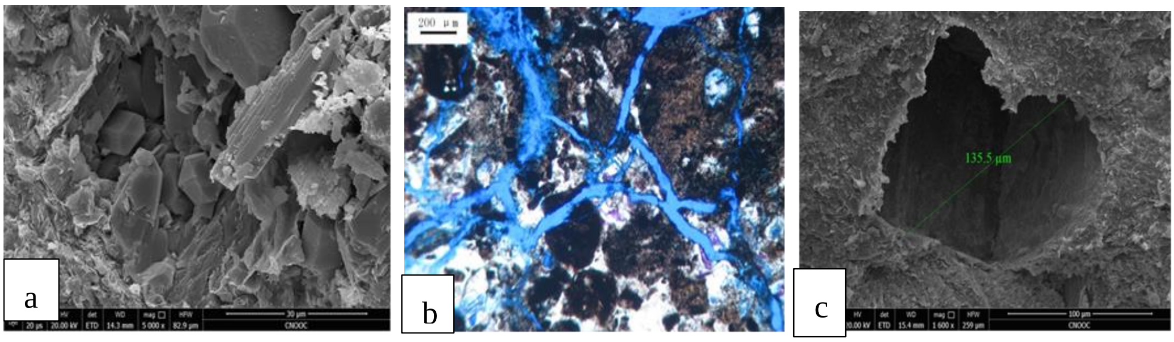


Figure 3. Reservoir space characteristics of volcanic buried hills in Mesozoic.

(a) Well KL16-1-4, 1604.05m, Mesozoic tuff, potassium feldspar dissolves along the cleavage, and secondary enlarged quartz and filiform illite fill the intergranular pores (SEM); (b) Well KL16-1-1, 1210m, Mesozoic tuff cast thin section, cracks (single polarized light); (c) Well KL16-1-4, 1610m, Mesozoic tuff, pore diameter of about 135 microns, mold dissolution holes (SEM)

## 5. Reservoir development control factors

### 5.1 Volcanic rock lithology

The lithology of volcanic rock is the internal cause that determines the development of its reservoir. The storage space of volcanic rock is mainly composed of residual fractures and broken fractures, with intergranular dissolved pores, matrix dissolved pores, and intragranular pores developed.

### 5.2 Tectonic movement

Tectonic movement is also an important factor controlling the development of reservoirs. Generally, the formation of fractures and unconformities is related to the power given by tectonic movement, and the shape of fractures and unconformities is often controlled by tectonic movement. Tectonic fractures can generate new storage space in the reservoir, and can also connect the originally independent pores in the reservoir, thereby improving the pore connectivity of the reservoir.

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Unconformities and fractures can be used as oil and gas migration channels, thereby improving the reservoir's storage capacity.

### 5.3 Diagenesis

During the cooling diagenesis stage of volcanic rock, part of the gas in the rock escapes, and a large number of pores are formed in the upper and lower parts of the volcanic rock, which are very important primary pores in volcanic rock(Wang et al,2012). In the condensation stage of volcanic rocks, due to cold shrinkage of the rock and the formation of shrinkage cracks and fracture zones due to crushing, it can not only serve as an effective storage space, but more importantly, it can connect the pores in the reservoir to form a relatively The good combination of pores and fractures greatly improves the permeability of volcanic rocks to a certain extent, and plays a great role in improving the storage performance of volcanic rocks.

## 6. Comprehensive Evaluation and Analysis of Reservoir

Through the exploration practice of volcanic rock oil and gas reservoirs, it is clear that the oil and gas content of volcanic rock reservoirs is related to the lithology and physical properties of the reservoir and the type of storage space of the reservoir.

The buried hill has strong heterogeneity and complex reservoir space. According to relevant data and experimental data, it can be known that the Mesozoic reservoirs in the KL16-1 structure of Laizhou Bay Sag are mainly volcanic clastic reservoirs, and their lithology is mainly volcanic. Breccia, tuff and dacite. Well KL16-1-1 encountered a Mesozoic buried hill volcanic rock formation of 59.92m, and the lithology is dominated by andesitic tuff; Well KL16-1-4 encountered a 62m Mesozoic volcanic buried hill formation.

It can be seen from the comprehensive reservoir evaluation diagrams of some single wells that have been completed, the Mesozoic volcanic rock reservoir is a set of relatively high-quality reservoirs, and its reservoir space types are mainly composed of fractures, dissolution pores and other secondary fracture pores. host. For example, Well KL16-1-1, it is a low-porosity and ultra-low-permeability reservoir. The reservoir type is mainly fractured pores. Type reservoir has relatively high acoustic value in logging response, high microspherical focus logging value, large difference in lateral resistivity amplitude between deep and shallow depths, and superior reservoir quality (Figure 4); in well KL16-1-4 A large number of pores and fractures of various types of volcanic rock reservoirs in the biosphere are developed, the acoustic wave value is relatively high in the logging response, the micro-spherical focus logging value is relatively high, and the reservoir quality is relatively superior.

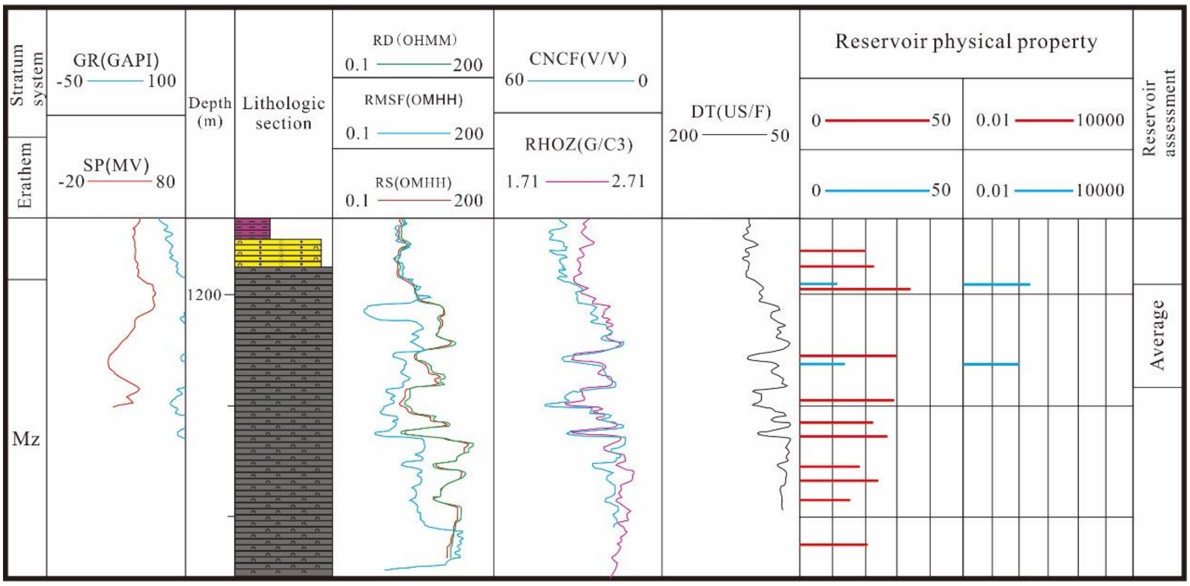


Figure 4. Comprehensive reservoir evaluation map of the Well KL16-1-1

## 7. Conclusion

(1) The Mesozoic volcanic rock reservoir of KL16-1 structure belt in Laizhou Bay Sag is mainly volcanic clastic reservoir, and its lithology mainly includes tuff, volcanic breccia and dacite, etc.

(2) The main storage space types of volcanic rock reservoirs include primary storage space and secondary storage space. The primary storage space includes intercrystalline pores, pores, and contraction fractures; the secondary storage space includes secondary dissolution pores and fractures, and structural fractures. , Weathering fractures, etc., in which secondary storage space is the main type of storage space for volcanic reservoirs in the study area.

(3) The controlling factors of reservoir development mainly include volcanic rock lithology, tectonic movement and diagenesis. Tectonic movement helps to change the connectivity of reservoir pores, and diagenesis helps to change the permeability of the reservoir.

(4) According to log data analysis, the reservoir in the study area is a low-porosity and ultra-low permeability reservoir, but due to its relatively developed fractures and pores, the Mesozoic volcanic reservoir in the study area is comprehensively evaluated as a set of relatively high-quality reservoirs.

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