Introduction

In recent years, volcanic has become an important new exploration field. However, due to the great heterogeneity of volcanic, the complexity of lithology & lithofacies, and the rapid spatial of phase transition, it is difficult to predict volcanic reservoir. Therefore, effective reservoir prediction becomes the difficulty of volcanic reservoir efficient development.

Conventional volcanic interpretation methods usually start from the volcanic reflection characteristics calibration by the well, the volcanic reflection characteristics on the seismic profile determine the volcanic range. However, due to the great difference in reflection characteristics of different volcanic types, there are many uncertainties.

Focused on the especial geological characteristics of carboniferous volcanic, such as early age, deep burial, poor quality of seismic data, complexity of lithology & lithofacies, overlapping of multi-period volcanic rocks, this study carried out the research of volcanic reservoir seismic prediction technology, and established the trinity volcanic reservoir seismic identification technology. Starting from the analysis of volcanic mechanism, through the source control, block control, facies control, step by step effectively reduce the multi-solution of volcanic reservoir prediction.

This method has been applied to the deep carboniferous volcanic in the junger basin. Based on logging data analysis and well-seismic calibration, the evolution analysis of volcanic eruption has been carried out, and the identification model of volcanic mechanism has been established, obtained a good the application effects.

Method

In view of the complexity of volcanic internal structure, from whole to partial, follow the trinity technology route of "source-volcanic mechanism, body-volcanic rock mass, facies-volcanic reservoir", to stepwise control the volcanic reservoir.

![Figure 1](image)

**Figure 1** volcanic reservoir seismic identification

①Source - volcanic mechanism identification: On the seismic profile (**Figure 1a**), the volcanic cone is usually located at a structural high or local high. Volcanic cones usually come in contact with surrounding rocks in the form of unconformity contacts. The volcanic cone has the characteristics of lenticular reflection, arc-shaped reflection, and plate-shaped reflection. Because of the shielding effect of volcanic rocks, the top of the volcanic cone shows a strong reflection; the reflection inside the volcanic cone is weak. The occurrence of the volcanic channel is almost upright or intersects with the surrounding rock at a high angle and passes through it.

②Block - volcanic rock mass analysis: On the basis of volcanic mechanism identification, the volcanic rock masses of different periods are analyzed and identified based on the analysis of changes in seismic reflection characteristics such as waveform and amplitude. The instantaneous phase profile (**Figure 1b**) can eliminate the interference of amplitude changes, and it is easier to identify the phase intersection relationship between volcanic rocks in different periods.
Facies - volcanic reservoir characterization: The volcanic reservoirs are obviously controlled by volcanic facies. The explosive and overflow facies near the crater are generally high-quality volcanic reservoirs. These two favorable lithofacies show reflection characteristics of medium-low frequency and medium-strong amplitude on seismic profile, and the sweetness attributes (Figure 1c) that can simultaneously express amplitude and frequency can well identify high-quality volcanic reservoirs.

Examples

This method is used to predict volcanic reservoir and analyze volcanic eruption evolution of deep carboniferous volcanic rocks in junger basin. First, through the well logging crossploting analysis we can get the geophysical characteristics of volcanic rocks:

![Crossplot of multi volcanic lithology & lithofacies](image1)

It can be seen in Figure 2 that the overflow facies has obvious high-density, high-speed and high-impedance characteristics; the sedimentary facies has obvious low-speed and low-density low-impedance characteristics; the explosive facies shows the medium-speed and medium-density, and the impedance of the explosive facies lies between the overflow facies and the sedimentary facies.

The different lithology of volcanic rocks is less distinguishable, but the differentiating between different lithofacies has a certain degree of recognizability, so it is feasible to identify volcanic facies with seismic.

Second, on the basis of well logging analysis, through well-seismic calibration, according to the drilling of known wells, the seismic identification model of the three major volcanic facies are established:

![Classic volcanic facies](image2)

— Figure 3 Classic volcanic facies
Explosive facies - seismic reflection characteristic of a mound-like shape, medium - low frequency, medium - strong amplitude, and random reflection. \((\text{Figure 3a})\)

Overflow facies - seismic reflection characteristic with medium - low frequency, medium - strong amplitude, good continuity, parallel-subparallel reflection structure. \((\text{Figure 3b})\)

Sedimentary facies - seismic reflection characteristics of a wedge – shaped shape, medium - weak amplitude, medium frequency, medium continuous, and parallel - subparallel reflection structure. \((\text{Figure 3c})\)

Finally, we use the sweetness attribute to analyze the volcanic eruption & evolution analysis, and establish the volcanic mechanism identification model:

\[\text{Figure 4 Distribution of volcanic reservoir}\]

\[\text{Figure 5 Volcanic apparatus recognition model}\]

Period I: This period is the beginning of volcanic activity. The volcanoes was mainly concentrated near the two deep faults in the south \((\text{Figure 4a})\). The eruption methods was mainly fissure-type. Large ancient faults that communicated with the basement were the main channels for magmatic eruption. The volcanic mechanism centered on the faults and spread on both sides \((\text{Figure 5a})\).

Period II: During this period, the volcanic activity was the most active. The volcanoes extended along the three major fault zones of northwest-southeast direction \((\text{Figure 4b})\). The eruption method was mainly a central single crater eruption. The volcanic mechanism spread cone-shaped outward with the crater as the center \((\text{Figure 5b})\).

Period III: During this period, the volcanic activity was also active. The volcanoes were mainly distributed along the northwest-southeast fault zone and the slope zone in the southeast \((\text{Figure 4c})\). The eruption methods were mainly volcanic eruptions with central craters. The weak stratum formed by the uplifting has become the main channel for magma eruption. The volcanic mechanism is a compound polycone with multiple craters and multiple centers \((\text{Figure 5c})\).
Conclusions

The trinity volcanic seismic identification technology starting from the implementation of volcanic institutions, determines the volcanic eruption center, volcanic crater, volcanic channel and volcanic cone, etc., then uses the instantaneous phase attribute to describe the volcanic rock mass to analyze the volcanic activity period, and finally uses the sweetness attribute to analyze the volcanic favourable lithofacies to identify volcanic reservoirs, this progressive analysis method is more more suitable for the special geological characteristics of volcanic, which can effectively reduce the multiplicity of volcanic reservoir predictions.

The feasibility of seismic identification of deep Carboniferous volcanic reservoir in Junggar Basin was analyzed by logging data analysis and well-seismic calibration. Multi-well lithology and lithofacies crossploting analysis confirmed that the volcanic lithofacies in this area have a certain degree of distinguishability, which is the basis of well for volcanic identification. Well-seismic calibration establishes different seismic reflection characteristics of three main typical lithofacies in the area, which is the seismic basis for volcanic identification.

Use the trinity volcanic seismic identification technology to identify the deep Carboniferous volcanic reservoir in Junggar Basin, and analyze the three periods of volcanic eruption & evolution. The volcanic activity is obviously controlled by the faults. In the period I volcanic activity was mainly concentrated near the two deep faults in the south. In the period II, volcanic activity extended along the three major fault zones of northwest-southeast direction. In period III, volcanic activity is distributed along the northwest-southeast fault zone and the slope zone in the southeast. Three types of volcanic mechanism identification modes have been established according to the different eruption methods and different eruption centers.

Acknowledgements

This work was supported by the Important National Science and Technology Specific Projects 2017ZX05001 of China, and CNPC Science and Technology Project 2017D-5006-16.

We also thank the Research Institute of Petroleum Exploration and Development, PetroChina Company Limited for allowing us to publish this work.

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