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Lithology and Lithofacies Identification of Permian Volcanic Rocks in Southwestern Sichuan

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Abstract

At the end of 2018, the Yongtan 1 well drilled by petrochina Southwest Oil and Gas Field Company in southwest Sichuan Basin encountered thick volcanic rocks and industrial gas flow in volcanic breccia lava, indicating that the Permian volcanic rocks in Sichuan Basin have broad exploration prospects. In order to further clarify the exploration prospect of Permian volcanic gas reservoir in western Sichuan, the characteristics and controlling factors of volcanic clastic reservoir in this area are systematically studied by means of geology, logging, geophysics and other techniques, and the exploration potential of natural gas in this area is discussed.(1) The log response shows that the volcanic rocks in Well Yongtan 1 can be divided into volcanic lava, pyroclastic lava and pyroclastic lava. The lithofacies is mainly pyroclastic eruption facies and basalt overflow facies. (2). The seismic facies model of volcanic rocks was established based on seismic response characteristics, and volcanic mechanism identification and volcanic facies characterization were carried out. Three types of seismic facies models can be identified: eruption facies, overflow facies and volcanic channel facies. (3). The identification and characterization of volcanic lithofacies and volcanic mechanism are carried out by extracting a variety of seismic attributes and optimizing the volcanic rock sensitive root mean square amplitude attribute, coherent body attribute and other attributes through attribute clustering and attribute fusion. (4). Reservoir prediction of volcanic rocks is carried out through wave impedance inversion. A comprehensive analysis of the results shows that the lithology and lithofacies identification by geophysical method is consistent with the subsequent drilling, which can be used as a guide for the subsequent volcanic work.

Keywords

Olcanic Rocks, In-Dustrial Gas, The Permian Volcanic Rocks, Basalt Overflow Facies.

1. Introduction

Since the 1950s, great breakthroughs have been made in the exploration of volcanic oil and gas reservoirs in China, including songliao, Junggar, Santanghu, Bohai Bay, Erlian, Tarim and Sichuan basins.As the main body of deep basin, volcanic reservoir will become an important field of oil and gas exploration for a long time in the future.

At the end of 2018, the Yongtan 1 well drilled by petrochina Southwest Oil & Gas Field Company in the Chengdu-Jianyang area encountered thick volcanic clastic lava with a measured daily gas output of 22.5×104m3 for the first time, revealing that volcanic rocks in the Sichuan Basin have great potential for gas exploration.

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Special volcanic rock reservoirs in sichuan basin formation, strong heterogeneity, influence factors, its distribution affected by volcanic multicenter phase of the eruption, the influence of the rapid accumulation characteristics, and less drilling, horizontal distribution is not clear, volcanic rock influence the spread of seismic wave, the seismic data obtained noise power is stronger, and low effective information to overlap in the frequency, It is difficult to show effective information. Conventional denoising methods have poor effect. At present, there is not a set of perfect research methods and theories to adapt to the research work of volcanic rocks in each block. Therefore, it is necessary to select effective theories and methods according to the specific conditions of volcanic rocks in different areas to identify and characterize the lithology and lithofacies of volcanic rocks in Sichuan Basin through existing geological, logging and seismic data.Based on logging response, seismic response, seismic attribute and wave impedance inversion, the lithology and lithofacies of volcanic rocks are identified and analyzed in this paper, so as to obtain an area with good oil and gas properties.

2. Logging Response of Volcanic Rocks

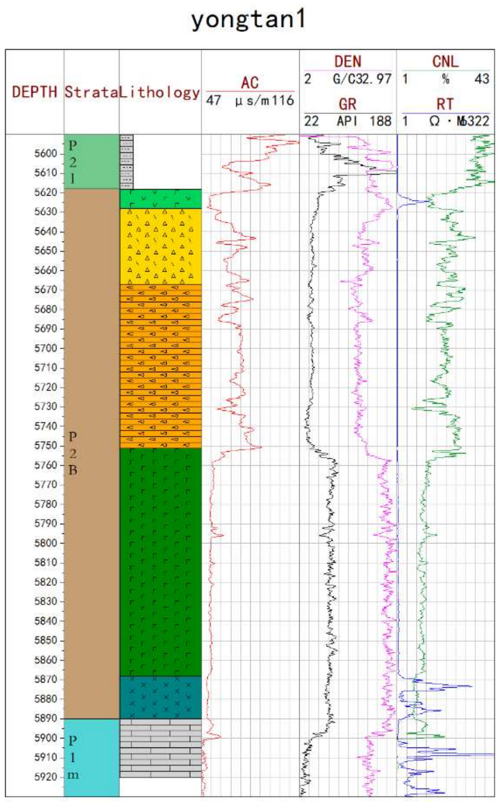

Figure 1. Comprehensive histogram of YT1

Well YT1 drilled 272 meters of Permian volcanic rock. The top and bottom were in unconformity contact with Longtan Formation mudstone and Maokou Formation limestone. There were mainly three types of pyroclastic lava, volcanic lava and diabase porphyrite. The log response characteristics of the volcanic rock of YT1 well are as follows: the sonic time difference of the volcanic rock is lower than that of the top mudstone, and slightly higher than that of the bottom limestone. The natural gamma curve has a clear bulge at the boundary between mudstone and volcanic rock, which is higher than that of the bottom limestone, and the density is greater than that of the bottom limestone. The density of limestone. Volcanic lava has the characteristics of low sonic jet lag, high natural gamma, and high density. Volcanic clastic lava has the characteristics of high sonic jet lag, low natural gamma, and low density. The upper thin-layer basalt and pyroclastic rock are formed by volcanic eruption, while the central basalt and bottom diabase porphyrite are formed by volcanic overflow.

Therefore, YT1 is divided into volcanic facies: eruptive facies, overflow facies. Pyroclastic lava of eruptive facies, large-sized volcanic agglomerated lava, and small-sized volcanic breccia lava have good porosity and permeability correlation and are good storage spaces for volcanic gas reservoirs. The overflow facies are developed with high degree of crystallinity and diabase porphyrite, and their porosity and permeability are different from that of explosion.

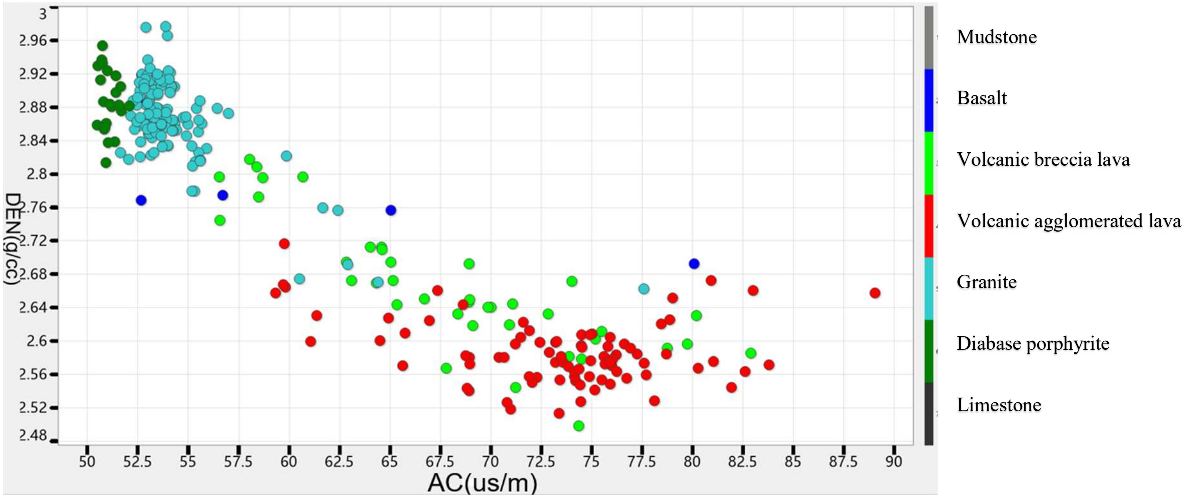

Figure 2. YT1. AC/DEN intersection

3. Volcanic Rock Seismic Response Characteristics

According to the reflection characteristics on the seismic profile, the reflection characteristics of volcanic rocks can be identified, and the reflection characteristic models of different lithological facies can be established to identify the volcanic rock facies. Two types of volcanic rock facies can be identified in the Yongtan 1 well area (Figure 3): (1) Eruptive facies: the top interface of the volcanic rock has strong reflections in the shape of a mound, with good continuity, there are multiple chaotic weak reflections inside, and the bottom of the volcanic rock The interface is weakly reflective, and the event axis is continuously different, and there is discontinuity. (2) Overflow phase: all seismic sections show parallel-subparallel reflections, with a certain degree of stability in the lateral direction, with strong reflection at the top and weak reflection at the bottom. There is no internal reflection, and the continuity of the event axis is good.

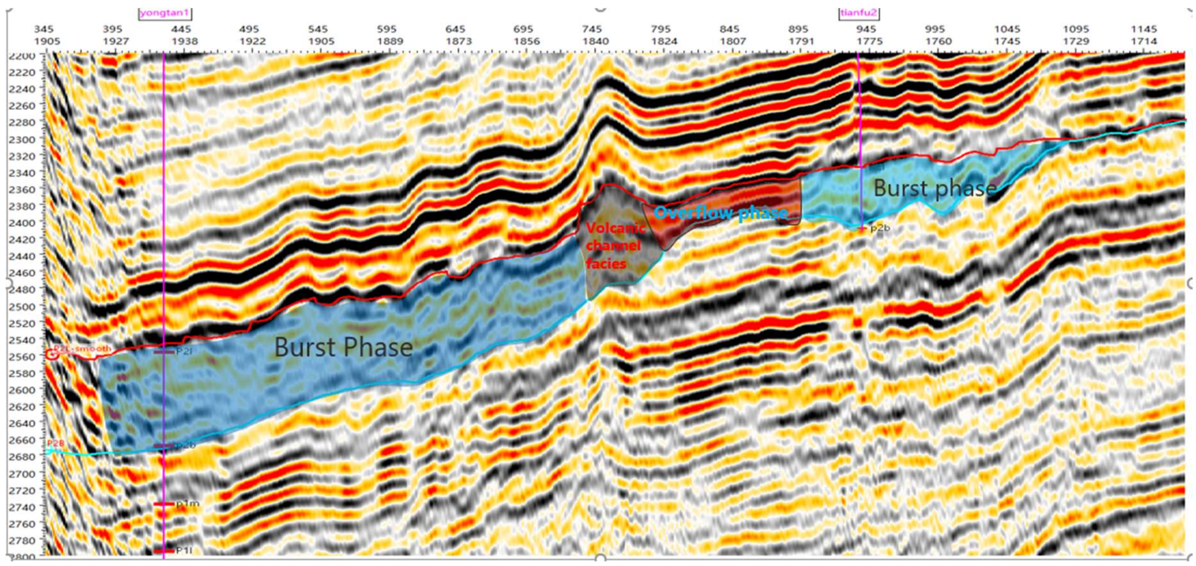

Figure 3. Seismic section of well Lianjing of YT 1-TF 2 well

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Among the two volcanic facies, the eruptive facies that mainly developed thick volcanic clastic lava has good porosity and the best storage properties. It is the most important reservoir rock for Permian volcanic rocks in southwestern Sichuan.

4. Analysis of Volcanic Rock Seismic Attributes

Seismic attribute analysis technology is an effective technology to identify volcanic structures and predict the spatial distribution and lithofacies characteristics of volcanic rock reservoirs. Seismic attributes are special measures of geometry, kinematics, dynamics, and statistics extracted from seismic data. It can highlight the information hidden in seismic data. Now there are more than 500 types of seismic attributes, so The key to this technology is to screen out the attributes that are sensitive to volcanic rock reservoirs among many attributes. In this experiment, the sensitive attributes of volcanic rocks were screened by extracting various attributes such as amplitude attributes and coherence attributes among volcanic rocks.

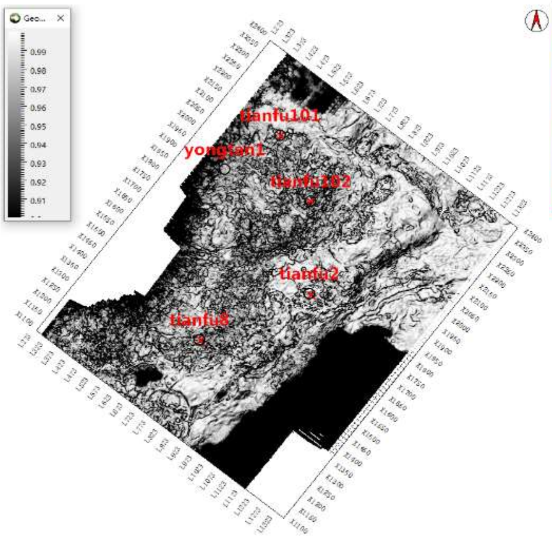

Figure 4a. Coherent properties

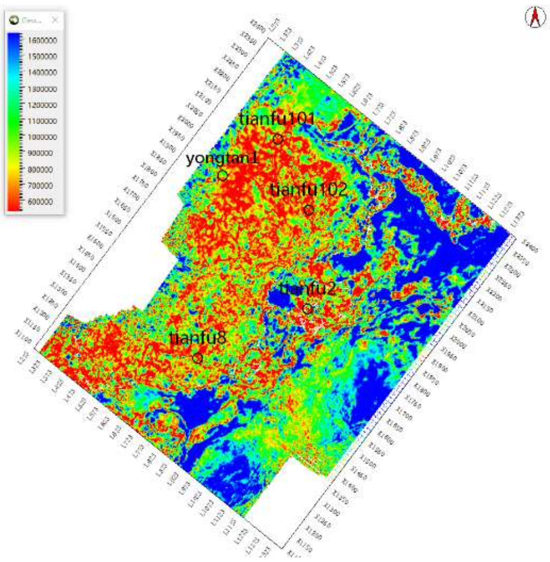

Figure 4b. RMS Amplitude properties

Through the extraction and screening of multiple attributes, the sensitive attributes, coherence attributes and root mean square amplitude attributes of volcanic rocks can be obtained. The coherence attribute is to seek common ground while reserving differences in seismic data, highlighting those irrelevant data. Highlight the change characteristics of the waveform characteristics between seismic traces, that is, the degree of similarity between each seismic trace. Differences in stratum physical properties or tectonic effects can make the changes in the stratum appear in the relevant conclusions, which can be used as a basis for lithological identification, fracture and fault identification. The root mean square amplitude is the square root of the average of the square of the amplitude. It is very sensitive to particularly large amplitudes. It can be used to identify sudden changes in amplitude caused by differences in lithology, lithofacies, and fluids in pores, and can be used to identify volcanic rocks.

5. Volcanic Rock Seismic Inversion

Inversion technology is an important means to predict volcanic rock lithology and oil and gas distribution in three-dimensional space. Seismic inversion technology has experienced decades of development, and dozens of inversion methods have been developed to form a relatively complete system for different Geological conditions can be inverted in different ways.

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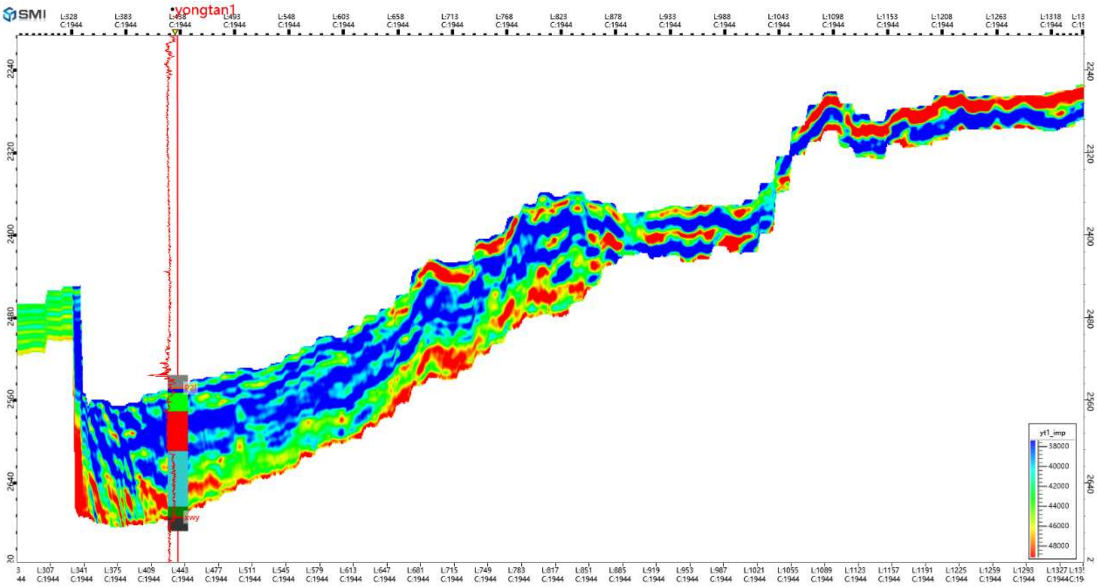

Figure 5. Wave impedance inversion profile of YT1

Through the wave impedance inversion profile, it can be seen in the figure that the volcanic clastic lava has low wave impedance, and the granulite, basalt, and diabase porphyrite of volcanic lava have strong wave impedance, which can be seen in the inversion profile. In Well Yongtan 1, there is low-impedance pyroclastic lava at the top and high-impedance volcanic lava at the bottom, which can be clearly distinguished in the figure, which is consistent with the wave impedance curve and the drilling conclusion.

6. Conclusion

(1) Logging conclusions show that the lithology of the volcanic rocks in Well Yongtan 1 can be divided into pyroclastic lava and volcanic lava; among them, pyroclastic lava can be divided into volcanic breccia lava and volcanic agglomerate lava according to its particle size; volcanic lava can be based on The degree of crystallinity can be divided into basalt, diabase and diabase porphyrite. The volcanic rock facies can be divided into eruptive facies, overflow facies, and volcanic channel facies.

(2) Seismic facies identification of Permian volcanic rocks in the Sichuan Basin can identify eruptive facies and overflow facies. The burst phase has a continuous strong peak reflection or a discontinuous medium-strong peak reflection top boundary, a weak reflection discontinuous bottom boundary, and a number of chaotic and intermittent reflections inside. The overflow phase is strong reflection at the top, weak reflection at the bottom is parallel, no internal reflection, good continuity.

(3) The seismic attributes of volcanic rocks can screen out the sensitive root mean square amplitude attributes and coherence attributes of volcanic rocks. The root mean square attributes reflect the volcanic lava blocks with strong amplitude in the volcanic rocks, and the weaker amplitudes are pyroclastic lava blocks. The coherent attributes Used to identify the continuous features of seismic traces, combined with root mean square amplitude attributes, its lithology distribution characteristics are clear.

(4) The inversion conclusion shows that the top of the volcanic rock is low-impedance pyroclastic lava, and the lower part is high-impedance volcanic lava, and it can be clearly distinguished in the figure.

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