Study on lithology identification method of carboniferous in the west wing chepaizi salient in western margin of junggar basin

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Abstract. Reservoir characteristics are important indexes for oil and gas exploration and development. Therefore, the identification of igneous lithology of target formation is carried out by using intersection diagram and mechanical parameter method according to the Carboniferous logging data of the west wing chepaizi salient in western margin of junggar basin. The results show that the study area is dominated by volcanic clastic rocks and sedimentary rocks. The cross-section and mechanical parameters method can be used to identify the lithology and obtain the corresponding physical parameters. Finally, this work has guiding significance for the exploration and development of Carboniferous reservoirs in the west wing chepaizi salient in western margin of junggar basin.

1. Introduction

With the continuous development of exploration and development technology, a large number of igneous reservoirs have been discovered, and igneous reservoirs have become the focus of oil and gas development. Qu et al. [1] studied igneous reservoir characteristics, diagenesis and pore dynamic evolution process through core correlation tests combined with sediment-related contents. Wang [2] determined igneous reservoir characteristics and established the reservoir genetic model based on logging data and statistical methods. Wang et al. [3] studied lithologic identification, reservoir characteristics and lithofacies development of igneous rocks by various methods. Zhao Wusheng et al. [4] constructed four lithology identification auxiliary parameters, and based on logging information, mathematical methods were used for lithology identification. Qi Qiquan et al. [5] analyzed the relationship between lithology and physical properties, and then established the lithology identification model by using the intersection graph method and neural network method. Zhao Xianling et al. [6] lithologic identification achievements based on well logging data provide lithologic basis for rhythmic feature analysis, sedimentary facies division, sedimentary environment interpretation and other geological research, and creatively divide the lithology of glutenite reservoir from the perspective of analyzing the grain size characteristics of rock.
Most of the above studies use a single method to identify igneous rock lithology, but the igneous rock reservoir is complex and the rock types are diverse. Therefore, further research on lithology identification of igneous rocks is needed. This thesis takes the Carboniferous logging in the west wing chepaizi salient in western margin of Junggar basin as the research object, and makes a comprehensive study on lithology identification of carboniferous igneous rocks in the research area by using logging data and other data in the research area. According to the analysis of rock types, most of the rocks in the study area contain tuffaceous components. It is necessary to identify the lithology of the rocks in the study area, so as to lay a foundation for the study of reservoir physical properties and reservoir space types.

2. Overview of regional geology and rock types

2.1. Regional geological outline

The west wing of chepaizi salient in western margin of Junggar basin in the research area is a sub-level tectonic unit in the western Junggar basin, and an ancient salient formed in the late stage of the hercynian movement and inherited for a long time. The salient has the characteristics of uneven uplift, with the highest piedmont uplift in Zaire, and the amplitude of uplift decreases from north to south. The west wing of chepaizi salient contains many strata, among which Carboniferous logging is located in the bottom layer.

2.2. Rock type analysis

Through the analysis of geological logging data, the two types of carboniferous rocks in the study area are igneous rocks and sedimentary rocks. Among them, igneous rocks are mainly tuff and tuffite, while the sedimentary rocks are mainly tuff sandstone, tuff mudstone and mudstone. Through the analysis of exploration, tuffaceous sandstone is the favorable lithology of the target interval in the study area, followed by tuffaceous and sedimentary tuffaceous, and tuffaceous mudstone and mudstone are the worst lithology.

3. Identification of lithology by crossplot method

The crossplot method is a common method for lithology identification. It usually uses well logging parameters which with better sensitivity, and then draws crossplot by two groups to identify lithology [6]. Through the analysis of logging sensitivity coefficient, the crossplot lithology analysis is carried out by selecting logging parameters such as acoustic time difference (AC), density (DEN), natural gamma ray (GR) and compensated neutron (CNL). The results are shown in Fig. 1–3.

![Figure 1. Density-sonic cross plots.](image1)

![Figure 2. Density-natural gamma ray cross plots.](image2)
As seen from Fig.1, it can be concluded that the overlapping areas of tuff and tuffaceous fine sandstone are large and concentrated, and can be distinguished from sedimentary tuffaceous rocks, but not from other lithologies. Additionally, as seen from Fig.2, it can be concluded that there are clear boundaries between tuff and tuffaceous fine sandstone and mudstone, tuffaceous mudstone and sedimentary tuffaceous rock group, which are easy to distinguish. At the same time, the boundary between mudstone and tuffaceous mudstone and sedimentary tuffaceous rock is obvious and easy to distinguish. However, the distinction between tuffaceous fine sandstone and tuff is not obvious, and the distinction between mudstone and tuffaceous mudstone is not obvious. Finally, it can be concluded from Fig. 3 that the boundary between tuffaceous fine sandstone and tuff can be clearly distinguished. 

The boundary between tuffaceous mudstone, mudstone and sedimentary tuff is obvious and easy to distinguish. In summary, in combination with Figure 1, Figure 2 and Figure 3, tuff, tuffaceous fine sandstone and tuffaceous rock can be better distinguished, but it is still difficult to distinguish between mudstone and tuffaceous mudstone.

4. Identification of lithology by crossplot of mechanical parameters

Rocks have serious heterogeneity. Poisson's ratio and modulus of elasticity of different types of rocks show different differences. Lithology identification can be carried out according to Poisson's ratio and modulus of elasticity. The P-wave time difference of rock can be obtained by logging data. Through the previous research results, the S-wave time difference can be obtained by P-wave time difference, and then the elastic modulus and Poisson's ratio of rock can be calculated. By establishing the crossplot of mechanical parameters and depth, different lithologies can be clearly distinguished. And the results are shown in the Fig. 4~5.
As seen in the Fig. 4, the tuffaceous mudstone and tuffaceous fine sandstone can be distinguished from tuffaceous rock. For mudstone and sedimentary tuffaceous rock, the distinguishing effect is not obvious. From the Poisson's ratio-depth intersection chart of Fig. 5, mudstone and tuff can be distinguished, and tuffaceous fine sandstone and tuffaceous can also be distinguished clearly. By synthesizing the intersection diagram method and the mechanical parameter method, different rock types in the study area can be distinguished, and the rock physical parameters table is shown in Table 1. The lithology of unknown points in the study area can be quickly determined by using logging data through the values of various physical parameters.

Table 1. Rock physical parameters in the study area.

| Lithology                   | GR/API  | AC/μs·ft⁻¹ | CNL/% | DEN/g·cm³ | Young’s Modulus /GPa | Poisson ratio |
|-----------------------------|---------|------------|-------|-----------|----------------------|--------------|
| Sedimentary tuff            | 58~82   | 57~83      | 12~26 | 2.26~2.59 | 15~36                | 0.17~0.22    |
| Tuffaceous Mudstone         | 54~90   | 59~75      | 13~24 | 2.16~2.65 | 19~37                | 0.18~0.23    |
| Mudstone                    | 75~105  | 57~76      | 13~27 | 2.43~2.63 | 22~38                | 0.18~0.20    |
| Tuff                        | 50~82   | 56~75      | 7~26  | 2.34~2.69 | 23~39                | 0.18~0.21    |
| Tuffaceous fine sandstone   | 50~93   | 58~66      | 10~18 | 2.53~2.66 | 31~39                | 0.18~0.19    |

5. Conclusion

The Carboniferous lithology in the study area is mainly divided into sedimentary rocks mainly composed of sedimentary tuff, volcaniclastic rocks mainly composed of tuff and tuffaceous mudstone, tuffaceous fine sandstone and mudstone.

The combination of conventional rendezvous diagram and mechanical parameter rendezvous diagram can identify lithology and obtain corresponding physical parameters, which has guiding significance for engineering practice.

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