Introduction

The carbonate reservoir is one of the most important exploration field in Sichuan Basin, which is thought to be the dominant natural gas production base. The study area is located in the northwest area of Sichuan basin, the targeted horizon is the Leikoupo Formation. The hydrocarbon is found in Leikoupo Formation during drilling, revealing a good exploration prospect for this area. Prior exploration experience has shown that the dolomite is the dominant Gas-bearing reservoir and the thin dolomite reservoir characterization is the key issue for further exploration of Leikoupo Formation.

Middle Triassic Leikoupo Formation underwent strong weathering and denudation, Leikoupo Formation of northwest Sichuan Basin is characterized with rich hydrocarbon resources, low proved rate of reserve and high potential of exploration. The main reservoir lithology is the dolomite dominated by grain-shoal facies and dissolution simultaneously, whose space is dissolved pore, poor connectivity between throat and pore, and fracture is not developed.

The top interface of Leikoupo Formation is the unconformity surface between upper clastic rock of Xujiahe Formation and underlying carbonate rock, forming the strong wave impedance difference, which exhibits the low frequency and continuous T3x1 strong peak reflection. Reservoir characterization with conventional seismic data does not work well. Combining the geological condition and drilling data of northwest area of Sichuan Basin, forward modelling is conducted to analysis the influence of shielding effect of T3x1 strong reflection and verify the feasibility of wavelet decomposition technique. Besides, field data application with seismic wavelet decomposition and reconstruction effectively weakens the shielding effect on underlying thin dolomite reservoir, and the comparison of optimized attributes demonstrate that the prediction results after wavelet decomposition are well-coincident with geology cognition and the new drilled well, which verifies that the technique have good application prospect for the thin-layer reservoir characterization with shielding effects.

Method and/or Theory

Seismic wave is the convolution between seismic wavelet and reflection coefficient of subsurface media, and conventional seismic processing and interpretation is mainly based on the hypothesis that the seismic wavelet is unchanged. Actually, the amplitude, phase and frequency of seismic wavelet varies according to different depth and oil-bearing properties, the real seismic traces can be regarded as the results of superimposition of multiple seismic reflections:

\[ S(t) = \sum R_n(t) * W_n(t) + N(t) \]

Where \( R_n(t) \) denotes the reflection coefficient of \( nth \) layer, \( W_n(t) \) denotes the wavelet of \( nth \) layer, and \( N(t) \) denotes the noise.

Seismic traces can be decomposed into various wavelets of different reflection coefficient, frequency and amplitude, then the seismic traces can be obtained by reconstructing the decomposed wavelets according to the requirement of actual work, thus suppressing the shielding effects of strong reflection and revealing more abundant information for reservoir characterization and fluid identification.

The wave equation forward modelling is one of the most effective ways to get some insight into the effectiveness of certain method. Considering the geological condition and elastic parameters from well logging, geological model of forward modelling is designed to illustrate the influence of shield effects of strong reflection on underlying seismic reflections. There are three layers from top to bottom, T3x1, T2l33, T2l32 respectively. The thickness of single reservoir is about 5 to 10 meters from well logging interpretation, so the reservoir thickness is set as 5 meters, and the dominant frequency is set as 0.20 according to the frequency analysis. As can be seen from Figure 1, when the distance between reservoir and bottom of T3x1 is smaller than 30 meters, the seismic response of reservoirs is obscure due to the shielding effect of T3x1 interface, while the weak peak reflection appears when the distance is greater than 30 meters. Seismic decomposition and reconstruction is conducted to remove the shielding effects of T3x1 interface, and the continuous and strong peak reflection is eliminated. The
weak peak reflection of reservoir seismic response can be revealed after wavelet decomposition and reconstruction, which suggests the effectiveness of the presented technique.

![Geological model(a) and the forward modelling results before(b) and after(c) seismic wavelet decomposition and reconstruction.](image)

**Figure 1** Geological model(a) and the forward modelling results before(b) and after(c) seismic wavelet decomposition and reconstruction.

**Examples**

Seismic wavelet decomposition and reconstruction method is applied to the 3-d seismic data of northwest Sichuan basin. The Figure 2 shows the comparison of synthetic seismogram from well sy001-1 and seismic data. The yellow zone represents the interpreted reservoir from well logging. As we can see, from shallow to deep, acoustic moveout on T3x1 interface sharply decreased, representing the unconformity between upper clastic rock and carbonate rock of Leikoupo Formation, which shows the reflection characteristics of continuous and strong peak. The weak reflection below T3x1 interface corresponds to the bottom of reservoir, however, the seismic data does not show the response of weak reflection due to the low seismic resolution. After seismic wavelet decomposition and reconstruction, seismic data is more consistent with the synthetic seismogram and the weak peak reflection between T3x1 and T2l33 interface can be highlighted. Besides, when the eliminated percent of strong reflection is high, the wavelet side lobes would badly affect the processing results. On the basis of testing different eliminating percent, it is found that 70% eliminating percent would both discriminate the seismic responses of reservoirs and avoid the wavelet side lobes. Through the comparative analysis of processed seismic traces and synthetic seismogram, the seismic wavelet decomposition method can suppress strong shield effects and improve the seismic resolution.

Figure 3 is the cross-well seismic section, the green line represents the T3x1 interface, which shows the continuous, low-frequency and strong peak reflection; the red line is the T2l33 interface characterized by continuous and strong trough reflection. There are little changes of the waveform between T3x1 and T2l33 interface, thus making it difficult to reflect the difference between reservoir and non-reservoir. Seismic decomposition and reconstruction technique is conducted with processing window 20ms above of T3x1 and 30ms below T3x1, which is aimed to contain the complete waveform. As can be seen in Figure 3, seismic data after wavelet decomposition and reconstruction...
removes the shielding effects of T3x1 strong reflection and enhance the resolution of target layer. As can be seen from the reconstructed section, the target layer of well yu1 is interpreted as dry layer corresponding to strong trough reflection, well st1 poor gas layer corresponding to composed-wave reflection, st3 and st7 gas layer with good physical property corresponding to weak peak reflection. The processing results is well-coincident with the drilling wells and reveals the difference between reservoirs and non-reservoirs.

**Figure 2** The comparison of synthetic seismogram from well logging with seismic data before and after wavelet decomposition and reconstruction.

**Figure 3** Cross-well seismic section before(a) and after(b) wavelet decomposition and reconstruction.

To further prove the reliability and application effect of seismic decomposition technique, reservoir prediction is conducted using optimized seismic attributes to analysis the reservoir distribution before and after seismic wavelet decomposition. Based on the above analysis, weak peak reflection between T3x1 and T2l33 interface appears when gas reservoirs developed, so the max peak amplitude attribute can be extracted to indicate the reservoir distribution. As we can see from the comparison of optimized attributes before and after wavelet decomposition, the warmer the color, the more developed the gas reservoirs are. From the attribute extracted from seismic data after
processing (Figure 4b), the gas wells sy001-1, st3, st8 and st7 are located in the area of warm color, gas well with poor reservoir property st1 is located in the edge of yellow color area, dry wells yu1 and st12 are located in area of blue color, which is more consistent with the drilling wells. Furthermore, the well st102 is a newly drilled well, which is located in the warm color of attribute extracted from original seismic data, meaning that the dolomite reservoirs are well developed. However, the drilling result indicate that reservoir of well st102 does not develop, which is in well agreement with the extracted attribute from data after wavelet decomposition.

![Figure 4](image)

**Figure 4** Max peak amplitude attribute of Leikoupo Formation before(a) and after(b) wavelet decomposition and reconstruction.

**Conclusions**

In this paper, seismic wavelet decomposition and reconstruction is presented to make it reliable to characterize meticulously the planar and section distribution of the thin dolomite reservoir in northwest Sichuan Basin. From seismic forward modelling, when the distance between reservoir and bottom of T3x1 is smaller than 30 meters, the seismic response of reservoirs is obscure due to the shielding effect of T3x1 interface. Through the comparative analysis before and after processing, the seismic wavelet decomposition method can suppress strong shield effects to improve the seismic resolution for reservoir characterization and fluid identification, which suggest the feasibility of the method for the thin-layer reservoir characterization.

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**References**

