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Study of sedimentary sequence cycles by well-seismic calibration

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Abstract: In order to solve the problems of the fine division of sedimentary sequence cycles and their change in two-dimensional space as well as lateral extension contrast, we developed a method of wavelet depth-frequency analysis. The single signal and composite signal of different Milankovitch cycles are obtained by numerical simulation. The simulated composite signal can be separated into single signals of a single frequency cycle. We also develop a well-seismic calibration insertion technology which helps to realize the calibration from the spectrum characteristics of a single well to the seismic profile. And then we determine the change and distribution characteristics of spectrum cycles in the two-dimensional space. It points out the direction in determining the variations of the regional sedimentary sequence cycles, underground strata structure and the contact relationship.

Key words: Sedimentary sequence cycles, wavelet depth-frequency analysis, well-seismic calibration, spectrum cycles, well logging

1 Introduction

Sedimentary strata are not only characterized by layered properties, but also cyclicity. The complicated periodic motions are mostly the superimposition of simple periodic motions with different periods in nature. Sedimentary cycles are the periodic repeating of sedimentary events (Mitchum and Van Wagoner, 1991; Wang et al, 2002; Rudman and Lankston, 1973). Though many experts and scholars have done a lot of research to separate these complex strata with multistage superimposition into single stratum of a single period by using Fourier transforms, short-time Fourier transforms, Periodogram methods and wavelet transform algorithms to solve problems of sedimentary cycles (Goldhammer et al, 1993; 1990; Doveton, 1994). These algorithms only extract the spectrum characteristics to analyze the variations in sedimentary cycles by simply processing a list of seismic data or well logging data, and both the accuracy and precision of sedimentary cycle analysis need to be further improved. All in all, the problems of frequency cycle variations in two-dimensional space remain unsolved. Moreover, the mechanism of analyzing sedimentary cycles by these mathematical algorithms is not clear yet.

Based on the current situation and above problems, this paper develops the method of wavelet depth-frequency analysis. The typical cycle—Milankovitch period cycle is obtained by a numerical simulation method (Meyers et al, 2008; Zheng et al, 2007), and the simulated composite signals have been separated into single signals of singe frequency cycle. This paper also develops the well-seismic calibration insertion technique which helps to realize the calibration from the spectrum characteristics of a single well to the seismic profiles. And then we determine the two-dimensional continuation properties of spectrum cycles. Hence it indicates the direction on the variations of the regional sedimentary sequence cycles.

2 Wavelet depth-frequency analysis method and numerical simulation of sedimentary sequence cycles

2.1 Wavelet depth-frequency analysis method

The wavelet depth-frequency analysis method is based on time-frequency analysis, and it uses a one-dimensional wavelet transform algorithm. The data at different depths are processed by using new methods of "frequency division

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