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Quantitative Engraving Technology and Application of Ordovician Carbonate Reservoir in Tarim Basin

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Abstract

In the Tazhong area of the Tarim Basin, the Ordovician carbonate fracture cave reservoir is an important oil-bearing strata. The quantitative engraving of its fracture-cavity carbonate reservoirs has always been a difficult point in this area. In this paper, based on the characteristics of the reservoir development of the Paleozoic carbonate fractures in the Tazhong area, the fracture holes are classified according to the differences and scales of the seismic response patterns: the first is the storage with the beaded seismic model. The second type is a reservoir with a non-beaded seismic mode. This paper mainly describes the reservoir quantitative engraving method of the first type of model. Reservoirs with bead-type seismic modes are analyzed by amplitude gradient properties and corrected by rock physics forward modeling to achieve quantitative engraving of such reservoirs; At the same time, combined with the drilling production dynamic data, the engraving parameter threshold value is corrected to improve the accuracy of the reservoir quantitative description. Applied the method in quantitative engraving of ordovician fracture caverns in Tazhong area, Tarim Basin, the results show that the static model of a single fractured cave reservoir is modified to the same fracture cavity aggregate with good connectivity and large area, which is more in line with the geological laws of the zone and can better match the production dynamic data. The method can effectively combine dynamic production data with static geology and seismic methods, and has important reference significance for quantitative engraving and reserve calculation of fracture-cavity reservoirs.

Keywords: Carbonate rock, fracture cave reservoir, reservoir engraving, classifying quantification.

1. Introduction

The Paleozoic marine carbonate rocks in the Tarim Basin have a depth of more than 7000 m. The carbonate rock reservoirs are of various types, with significant differences in size and morphology, and strong heterogeneity. According to the shape and size, the reservoir space can be divided into three categories: holes, pores and cracks. According to the different spatial combination characteristics of holes, holes and seams, the fracture-cavity reservoirs can be divided into four types: cave type, hole type, crack-hole type and crack type. The corresponding seismic reflection modes are beaded strong reflection, Flaky strong reflection, messy reflection, weak (blank) reflection; the accuracy of prediction of carbonate reservoirs using seismic data is low. In addition, during the drilling process, cave-type reservoirs are prone to venting or loss of drilling fluid, resulting in missing or distortion of the logging curve, making it more difficult to predict reservoirs. Therefore, in order to improve the accuracy of carbonate reservoir

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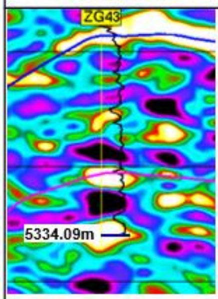
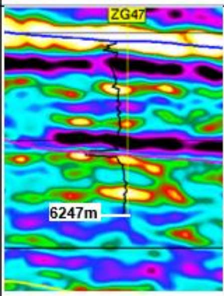
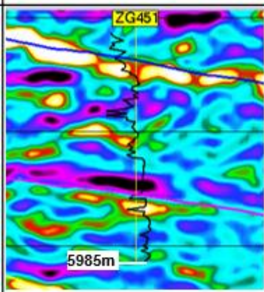
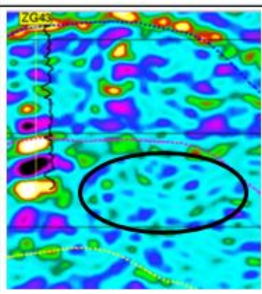
prediction, this paper proposes that based on geological interpretation, based on the differences and scale of seismic response patterns, based on static data, combined with production dynamic data, make quantitative engraving of heterogeneous fracture cave reservoirs.

2. Reservoir quantitative engraving research method of beaded and flaky reflection modes

According to the fine calibration of drilling and geological data in the Middle and Lower Ordovician carbonate reservoirs in the Tazhong area, the seismic reflection characteristics of large caves and pore aggregates are beaded and flaky, as shown in Table 1. This type of reservoir is the main fracture reservoir for obtaining high-yield oil flow in this area. The effective porosity is greater than 4.5%, and the fracture porosity corresponds to a large seismic response amplitude (absolute value greater than 3500), which is classified into one category. The second type is the seismic response of the non-beaded chaotic reflection mode. It mainly analyzes small-scale pores, fractured holes and fracture reservoirs. It is the secondary reservoir for obtaining oil and gas, with porosity of 2%-4.5%, crack pores. The degree is greater than 0.04%; the magnitude of the seismic response amplitude of the disordered reflection is small.

Table 1. Correspondence analysis table of reservoir type and seismic reflection mode

Reservoir type	I	II	II	III
Reservoir space characteristics	Caves and large-scale holes	Small-scale holes and cracks-hole type	a large number of small holes	No holes are developed
Seismic reflection mode	Beaded strong reflection	Flaky strong reflection	Messy reflection	Blank reflection
				
	frequency range: 5-65HZ, main frequency: 18HZ, amplitude: -7300~5450	frequency range: 4-65HZ, main frequency: 17HZ, amplitude: -3835~4660	frequency range: 3-62HZ, main frequency: 16HZ, amplitude: -2300~2230	frequency range: 5-60HZ, main frequency: 16HZ, amplitude: -900~1480
Porosity	Φ≥4.5%	Φ:3~4.5% Φf ≥0.04%	Φ:1.8~3% Φf ≥0.04%	Φ<1.8%

Through reservoir seismic calibration and geological interpretation, the beaded and flaky seismic reflection modes are mainly the response characteristics of large caves and large fractured cave aggregates. The seismic facies classification technique using multiple seismic attributes uses a Bayesian probability model to cluster multiple seismic data. The multi-seismic geometric properties are used to constrain the interpretation of seismic facies. The amplitude gradient properties can predict large caves and large seams. The spatial distribution of reservoirs in cave assemblies, but to achieve quantitative engraving of such reservoirs, the correction coefficients obtained from rock physics forward modeling are needed to accurately predict and quantify the fracture reservoirs.

According to the development scale of the fracture hole revealed by the drilling geology and imaging logging, and the difference between the longitudinal and transverse wave velocity and density of the reservoir and the surrounding rock, a variety of karst cave and dissolved pore geometry models are established to simulate the wave field forward, as shown in Fig. 1. It is difficult to accurately determine the specific shape of a single cave from the actual observed seismic reflection response; when the longitudinal and lateral spacing of the two caves is less than 60m (design surface element 25*25m), it is indistinguishable in seismic reflection response; single cave The larger the seismic reflection response, the larger the shape.

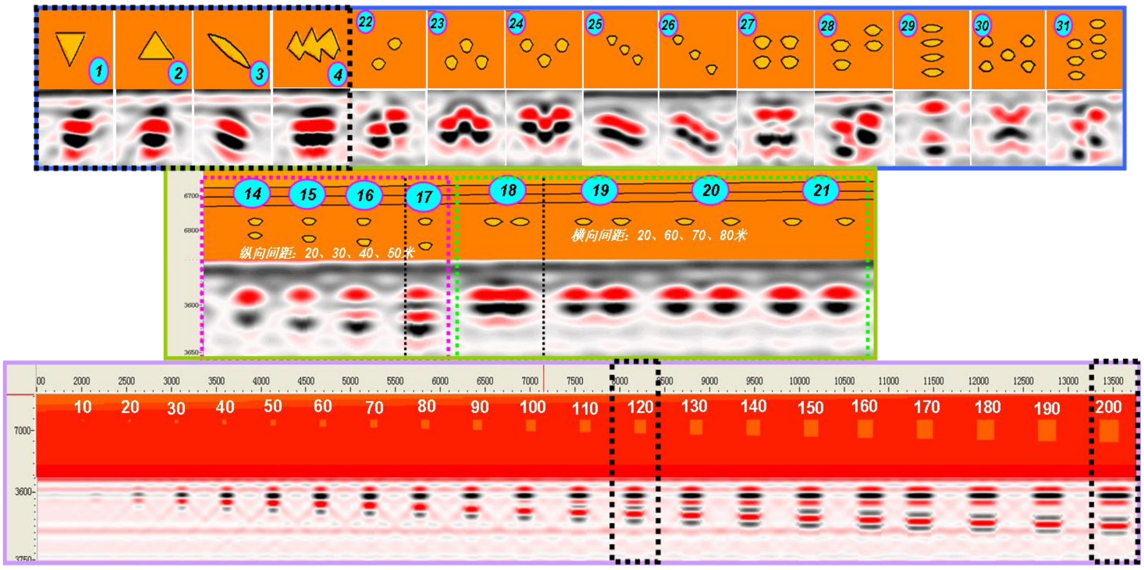


Fig. 1. Forward simulation results of karst cave models with different shapes, different combinations and different vertical and horizontal spacings

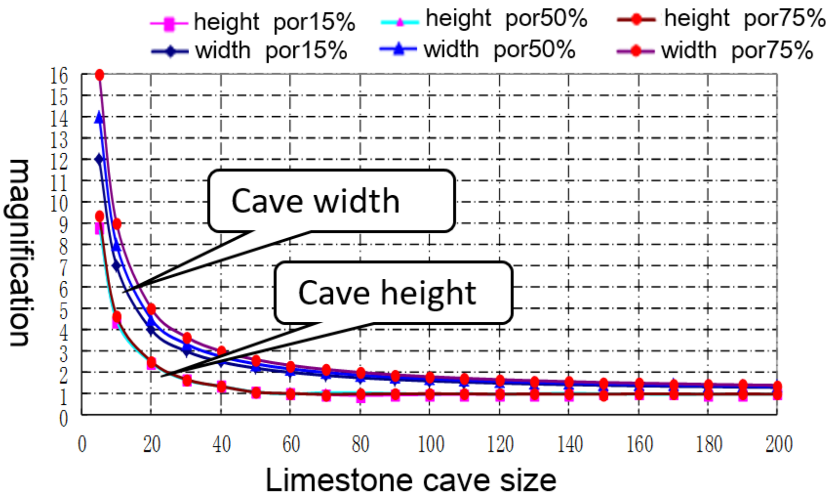
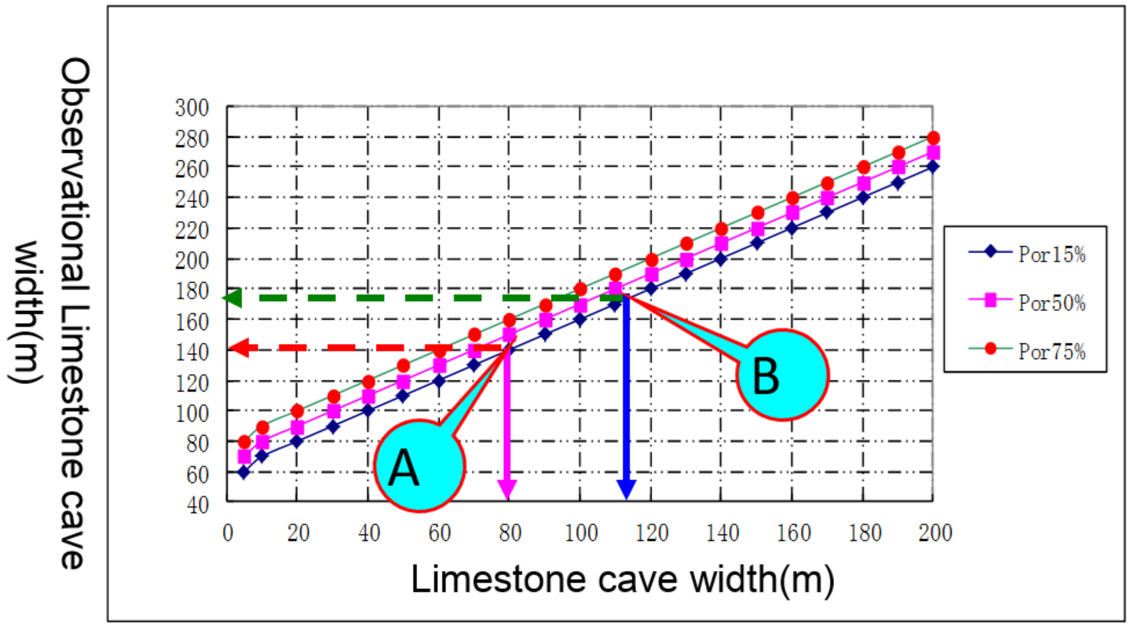


Fig. 2. The fracture hole model forward magnification coefficient relationship diagram

The forward results show that the magnitude of the seismic reflection response does not represent the actual size of the fracture cavity model. The beaded or flake reflection mode in the forward modeling seismic record is a magnification of the underground fracture reservoir. The response characteristics, and the actual size of the fracture reservoir is nonlinear with its magnification on the seismic reflection mode. The larger the fracture reservoir, the smaller the magnification. Fig. 2 shows a comparison of the size of the actual fracture cavity geometry model with the statistical analysis of the forward seismic response.



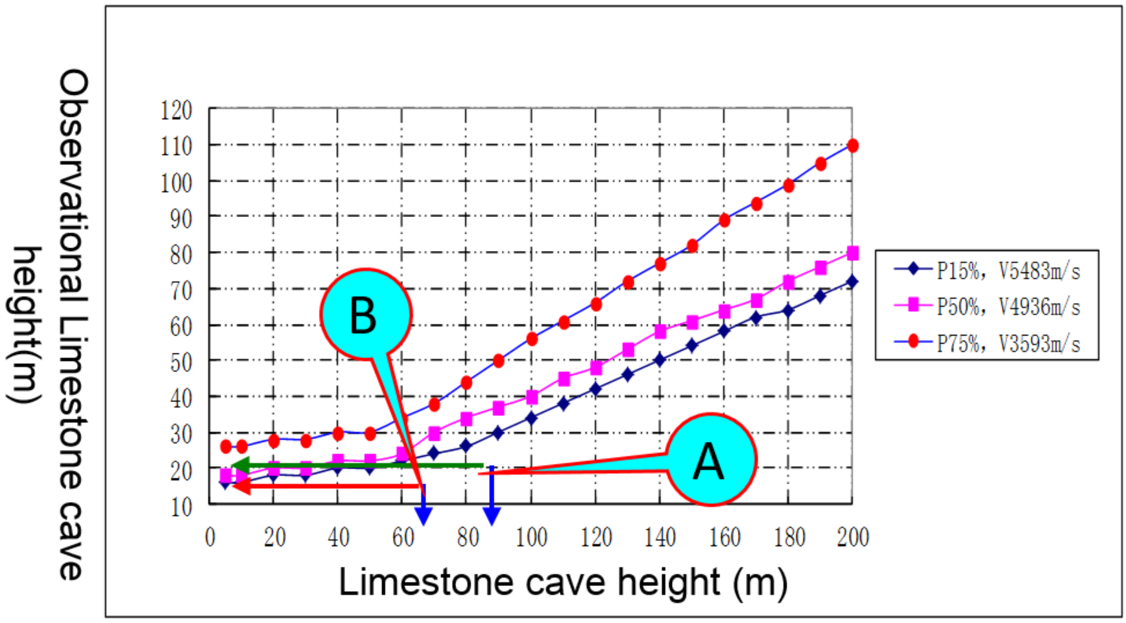


Fig. 3. Fracture hole model forward width (left), height (right) correction plate

The calibration coefficient interpretation chart of the actual model data of the observed data is created by counting the width and height of the geometric model of the plurality of fracture holes and the width and height observed in the seismic record corresponding to the model, as shown in Fig.3. For point A, when the width and height of the fractured reservoir are 140m and 20ms respectively (the speed is 6000m/s and the height is 600m), the observation volume is 1.176 million m^3, and the corrected actual width and height are 80m respectively. 60m, the corrected volume is 384,000 m^3, and the correction coefficient is 0.3265. For the same point, for point B, the observation volume is 2.388 million m^3, the corrected volume is 1.003 million m^3, and the correction coefficient is 0.42. After a lot of statistical analysis, the volume correction coefficient of the fracture model of the study area is 0.373. Thus, the product of the apparent volume of observation and the correction factor is the volume of the fracture-cavity reservoir.

Using the logging interpretation data of the actual well in the Tazhong area of the Tarim Basin, the error analysis of the correction coefficient obtained by the forward model is performed. According to the correction coefficient plate, the relative error between the reservoir height and the well interpretation height is less than 7%, as shown in Table 2. In the actual volume quantitative calculation, the proportional coefficient 1/k of the actual seismic observation volume and the actual fracture cavity volume is 0.373, and the calculation method is reliable.

Table 2. Comparison of the height of the fractured hole and the actual log interpretation height after the forward correction

Well name	Observation height(ms)	Forward correction height (m)	Log interpretation height (m)	Relative error	Average relative error
TZ1	21	36	34	-5%	6%
TZ2	18	31	33	6%	
TZ3	24	46	49	7%	

3. Application Effect

The quantitative engraving method of carbonate reservoirs in the beaded or flaky reflection mode has been widely used in the Tarim Basin and has achieved good results. In the application of quantitative engraving of carbonate rock fractured reservoir in TZ area, combined with drilling production dynamic data, the engraving parameter threshold is corrected to improve the accuracy of reservoir quantitative description.

Taking the quantitative engraving of the A1 well hole in the TZ area as an example, the well is carved into a single fracture cavity reservoir model by static data; however, it can be known from the production dynamic data that the well A1 in the TZ area starts to be tested on March 24 of a certain year. Mining, with 5mm nozzle production, as of April 14 of the following year, a total of 15,900 tons of oil production, cumulative gas production of 211.6 million m3. Among them, water began to appear on September 15 of the same year, and the water cut dropped to zero on October 14 (analyzed as partial seal hole water, cumulative production of water 1545t), then the natural gas production of the well suddenly increased, production 95 days without declining, accompanied by The gas to oil ratio rises, as shown in Figure 4 for the well production curve. The analysis concluded that the well communicated adjacent fractured holes in the later stages of production, forming a reservoir unit with the same pressure system. According to this, the threshold value of the quantitative engraving is adjusted, and the static model of the single fracture cave reservoir is corrected to the same fracture cave reservoir model with good connectivity and large volume. As shown in Fig. 5, the quantitative engraving of the two types of fracture cave reservoirs is shown. Schematic, yellow is the quantitative engraving result of the beaded seismic reflection, and blue is the quantitative engraving result of the sheet reflection mode. The method effectively combines dynamic production data with static seismic and geological data to minimize the amplification effect of the seismic response mode. Based on the quantitative engraving after volume correction, the calculation of carbonate reserves is carried out, and the reserve precision is greatly improved.

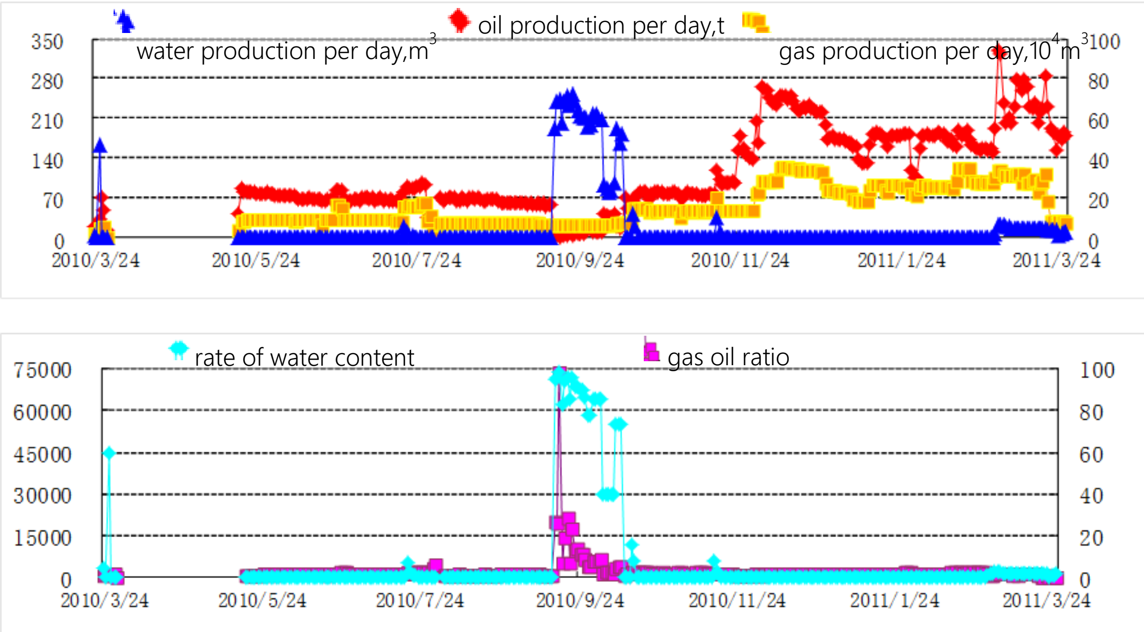


Fig. 4. Dynamic production curve of well A1 in TZ area

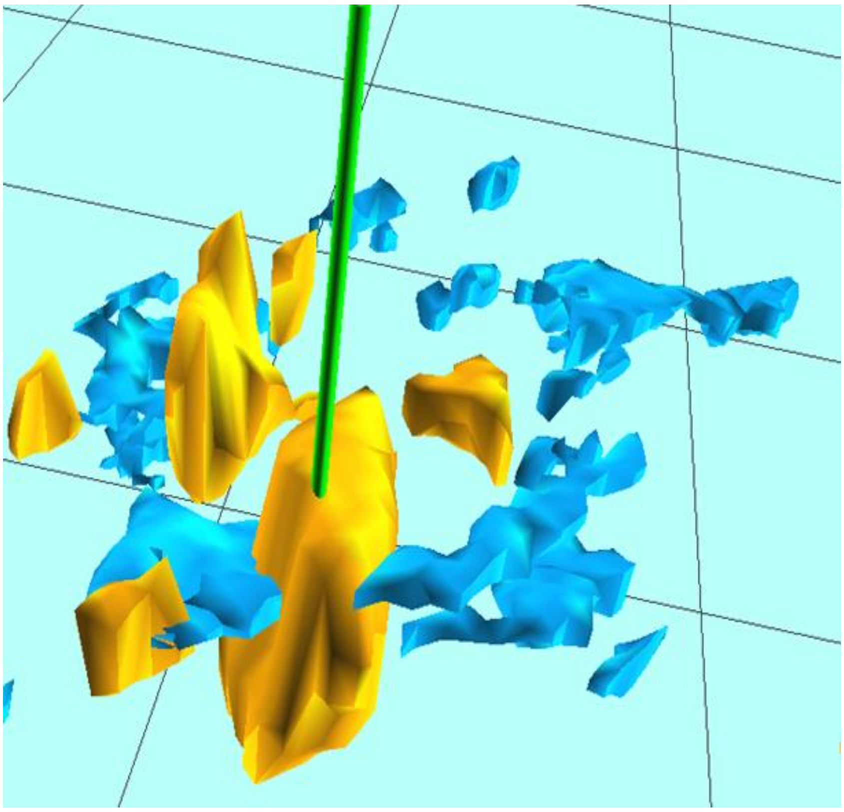


Fig. 5. Quantitative engraving of A1 well in TZ area

6. Conclusions and Suggestions

According to different seismic response modes of different carbonate reservoir types, the reservoirs are classified and studied. For the “beaded” or “flake” reflective fracture reservoirs, the forward volume correction method is used to realize Reservoir volume quantitative engraving. The amplification effect and multi-solution of the seismic response are greatly reduced, and the accuracy of the quantitative description of the reservoir is improved.

Based on the static description of the fracture-cavity reservoir by seismic and logging data, the engraving threshold is corrected according to the production dynamic data, and the organic combination of dynamic data and static data is realized, and the connectivity of the fracture-cavity reservoir is analyzed. Reserve research has important reference significance.

For the quantitative engraving of reservoirs in the “beaded” or “flaky” reflection mode, since the reservoirs are mainly composed of large caves or fractured hole assemblies, the integrity and accuracy of logging data and geological data acquisition are affected. Therefore, the method is based on the contour characterization and volume correction of the seismic attribute body; there are limitations on the description of the internal structural features of the fractured hole reservoir; it is recommended to refine the different shapes, different combinations, and different filling levels of the fractured hole model. Perform simulations to analyze changes in seismic response patterns and improve the accuracy of the correction factor template.

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