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Prediction of Three Pressures and Wellbore Stability Evaluation Based on Seismic Inversion for Well Huqian-1

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Abstract

The abnormal pore pressures in ultra-deep wells in the Junggar Basin, China are constantly causing drilling incidents for both the drilling engineers and geologists. Formation pore-pressure is an important parameter in wellbore stability analysis, and accurate prediction of pore pressure before drilling is of great significance for effectively controlling wellbore instability. In this paper, the authors utilize seismic velocity inversion and rock mechanics prediction to evaluate the three pressure parameters, i.e., pore pressure, collapse pressure, and fracture pressure. Seismic data were inversed and the velocity model was constructed. Then, the layering models of the relationships between seismic velocity and logging data of the whole formation layers were constructed using seismic attributes and the corresponding acoustic logging data. Finally, the acoustic logging data, or interval transit time of ten corresponding formations, were predicted using layering models of seismic data. In an ultra-deep well, two abnormal highly pressurized sections were confirmed. This shows great potential for realizing real-time prediction of acoustic and density log data of undrilled formations in this area. Field applications confirm that the proposed method enhances prediction accuracy and computational efficiency compared to the Eston method. Two abnormal high-pressure zones were successfully identified in the Huqian-1 well, i.e., the Taxihe Formation (1.38 g/cm^3) and the Anjihaihe Formation (1.50 g/cm^3).

Keywords: wellbore stability; seismic inversion; pore pressure; collapse pressure; fracture pressure

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1. Introduction

In the field of deep exploration drilling, wellbore stability is commonly evaluated by predicting the safe drilling fluid density limits or window [1–3]. This could effectively overcome the instability problems such as wellbore collapse and fracture incidents that frequently occur during the drilling process. In the Hutubi anticline, southern margin of the Junggar Basin of China, few deep exploration wells were being penetrated up to 8,000 m in depth, as shown in Figure 1. In 2019, the daily oil production of the two

exploration wells Gaotan-1 and Hutan-1 reached 1213 m^3 and 106.5 m^3, which attracted lots of attention and brought a huge number of investments from PetroChina to this new exploration area [4]. Due to long-term multi-layer compression and thrusting activities, the local drilling activities had encountered severe drilling incidents, i.e., wellbore collapse, drill tool jamming, and wellbore breakout, etc. In addition, the abnormal high-pressure formations frequently occurred, which remained out of the control of geologists and drilling engineers. For the last few years, the abnormal high-pressure formations constantly existed, and the mechanisms remained unclear for both geologists and drilling engineers.

To predict the wellbore stability for exploration wells, there are generally four types of wellbore stability prediction methods, i.e., statistical models, trend profile models, neural networks, and rock mechanical models [5]. The statistical relationship model is established by correlating the upper and lower limits of the safe drilling fluid density and the layer velocities. This model is applicable for a specific geologic structure based on existing data such as layer velocities and the upper and lower limits of safe mud densities. The statistical approach depends heavily on historical data from specific geological settings but faces challenges in generalizing across diverse formations. Trend profile methods employ polynomial fitting to link depth, velocity, and density, though they often fail to address complex nonlinear relationships. Neural networks excel at capturing nonlinear patterns but demand large training datasets and offer limited interpretability. The input layers of this network consisted of overburden pressure gradient, well depth, and layer velocity. The output layers consisted of collapse pressure and fracture pressure. After sufficient learning of the model, pre-drilling wellbore stability could be effectively evaluated [6–8]. In contrast, rock mechanical models leverage physical principles to directly relate formation mechanical properties to wellbore pressures, making them particularly effective in areas with sparse logging data [9].

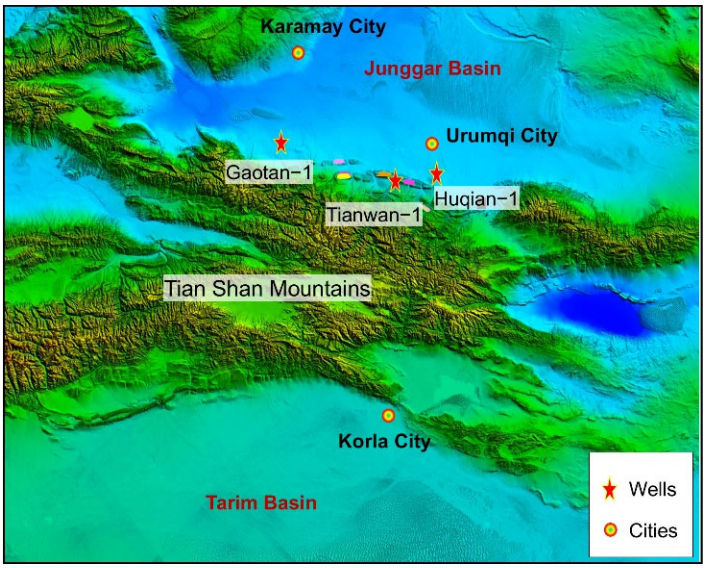


Figure 1. Satellite view of south margin area of the Junggar Basin, China [10].

The existing research mainly focuses on layered velocity-based techniques to evaluate the borehole stability for pre-drilled wells [4], which takes advantage of higher resolution and higher accuracy than the seismic record processing method [10–13]. In this prediction technology, multi-types of geologic and drilling engineering data are utilized, including drilling, logging, and seismic, to establish a relationship between safe drilling fluid densities and layer seismic velocities. This facilitates the prediction of the upper and lower limits of safe drilling fluid densities for those pre-drilled wells. Unfortunately, the layer velocity is

generally derived from the seismic spectrum method, which is characterized by deficient accuracy and low resolution in the datasets [14]. In addition, this spectrum method itself requires extraordinary skills from the researchers and rarely satisfies the final quality check standards. Later, some researchers proposed a modified method based on seismic layer velocity inversion for pre-drilling wellbore stability prediction. This prediction method fully employs on-site data, taking advantage of seismic and logging information, which could be widely promoted and applied.

This study introduces a novel layered prediction framework that combines seismic velocity inversion with the rock mechanics model. By integrating these approaches, the proposed method reduces reliance on conventional logging data and achieves dynamic 3D pressure field predictions with enhanced practicality. In this paper, the authors present a method of utilizing multiple sources such as geologic, engineering, logging, and seismic inversion to evaluate and predict wellbore stability for formation layers. The whole procedure demonstrates the feasibility of seismic inversion in highly precise wellbore stability prediction for prospective deep oil and gas resources.

2. Methods

Based on logging interpretation, we calculated the rock mechanics parameters, such as Young's modulus and Poisson's ratio, for multiple layers and determined the in situ stress status. By constructing the inversed velocity model, seismic velocities were correlated with geomechanics properties. Then, the collapse and fracture pressures were calculated based on the mechanics analysis for wellbore stability. In this way, we predicted the safe drilling fluid density limits and evaluated the wellbore stability for those pre-drilled wells.

2.1. Fundamentals of Layer Seismic Inversion

Seismic velocity inversion can be divided into two categories based on the following principles: convolution model-based inversion and wave equation-based inversion [15,16]. In this paper, we applied the logging constrained inversion method, which is based on the convolution model. According to the principle of seismic exploration, the convolution of seismic wavelets and reflection coefficient sequences can be approximated as synthetic seismic records, and this operation process can be expressed as follows [17]:

$$f(t) = r(t)s(t) \tag{1}$$

where $f(t)$ is the synthetic seismic record, $s(t)$ is the seismic wavelet, and $r(t)$ is the reflection coefficient sequence. The calculation of the reflection coefficient is based on acoustic and density logging data, and the calculation formula is given as follows:

$$r_i = \frac{\rho v_{i+1} - \rho v_i}{\rho v_{i+1} + \rho v_i} \tag{2}$$

where r is the reflection coefficient, ρ is the density, v is the sonic velocity, ρv is the acoustic impedance, and the subscripts i and $i+1$ denote the i^{th} and $(i+1)^{th}$ layers, respectively.

This layer seismic inversion method extracts seismic wavelets and establishes an initial wave impedance model based on known regional seismic records, logging data of neighboring wells, and geological data. Using this model, the wave impedance parameters of the formation could be predicted, and the velocity for every layer of the formation is eventually calculated. The major steps include preprocessing of logging data, establishing initial geological models, creating synthetic seismic records, and inversion calculations.

2.2. Pre-Processing of Logging Data

In the process of seismic velocity inversion, the logging data types include acoustic and density logging data [18]. Before inversion, the distortion points in the logging curves were required to be removed for those outside the practical range of the logging parameters, which was called environmental correction. In addition, two methods were employed to finish the standardization process, i.e., the standard layers-based system drift correction and the formation plane smooth correction. The sampling interval of logging data was generally measured in depth, while the sampling unit of seismic data was usually the seismic round-trip travel time. When the interval difference of two sampling data became significant, it required the median filtering and depth–time conversion for the logging data.

2.3. Synthetic Seismic Records

Synthetic seismic records are the link between seismic records and measurement data [19,20]. The purpose of creating synthetic records is to accurately calibrate the reflection positions of various lithological interfaces on seismic profiles. The accuracy of layer calibration depends on the quality of synthetic seismic records, which is closely related to seismic wavelets. First, under the guidance of the initial time–depth relationship, a standard theoretical wavelet was applied to produce the initial synthetic seismic records. Then, these records were compared with the wellbore seismic record for time–depth correction of logging curves. Finally, the wavelets were iteratively modified based on the corrected logging data and the output records were treated as the standardized wavelets. Based on these new wavelets, synthetic seismic records were produced and compared with the seismic records of the well side, followed by the time–depth correction. The process of comparing seismic records was repeated until the optimal match was reached, resulting in the final synthetic seismic records.

2.4. Establishment of Initial Wave Impedance Model

Establishing the initial wave impedance model is mainly based on interpreted stratigraphic layers and relevant neighboring logging data. The establishment of this model could correlate the seismic interface information, that continuously changes, laterally with the measured common wave impedance data. This effectively controls the range of the solution and constrains its structure, which is fundamental to reduce the ambiguity of the inversion results. Therefore, the rationality of the initial wave impedance model directly affects the accuracy of the inversion results [21,22].

On the seismic profile, the major reflection layers were selected, and some control points were selected. The interpreted wave impedance curves were applied to calibrate these control points, along with geology data. Then the interpolation was conducted internally and externally. The most widely used interpolation methods include the inverse distance squared weighted interpolation, kriging interpolation, and fractal interpolation. Based on this procedure, the initial wave impedance model was established.

2.5. Inversion Calculation

The classic generalized linear inversion is achieved by the following procedures. The forward modeling results of the initial model were compared with the actual seismic profile. Based on the errors, the forward models were then iteratively modified to approximate the actual data, thus resulting in the final inversion model [23]. Assume S as the seismic record, I as the wave impedance model, and the forward model of S and I is given as follows:

$$S(I) = S(I_0) + \frac{\partial S(I)}{\partial I}\Big|_{I_0} \Delta I \tag{3}$$

$$I = \rho v \tag{4}$$

where I_0 is the initial wave impedance, $\frac{\partial S(I)}{\partial I}$ is the sensitivity matrix, ΔI is the impedance error between forward modeling results and actual results, ρ is the rock density, and v is the velocity of acoustic waves.

From the above equation, the least-squares solution becomes [24]

$$\Delta I = (AA^T + \sigma_n^2 \sigma_m^{-2})^{-1} A^T \Delta S \tag{5}$$

where A is the Jocobi matrix, σ_n is the variance of noises within records, σ_m is the variance of modelling records, and ΔS is the difference between recorded and synthetic seismic records.

Based on the above principles, seismic, logging, and geologic data were employed in the broadband constrained inversion method. This process was based on the logging data, which was constrained by the seismic data, aiming at obtaining the optimal broadband wave impedance model.

2.6. Seismic Impedance Correlated with Wellbore Stability

Some researchers gave the relationship between seismic properties such as velocity, density, and pore pressure as follows [25]. Based on the definition of seismic impedance, the seismic impedance is mapped and correlated with pore pressure, collapse pressure, and fracture pressure [3].

$$v_p = B_0 + B_1 \rho + B_2 \sqrt{V_{sh}} + B_3 [100(\sigma_v - p_p) - e^{100 B_4 (\sigma_v - p_p)}] \tag{6}$$

$$V_{sh} = a_1 + a_2 v_p + a_3 v_s \tag{7}$$

where v_p is the p-wave velocity, v_s is the s-wave velocity, V_{sh} is the mass percentage of clay in rocks, σ_v is the overburden in-situ stress, and p_p is the pore pressure, a_1, a_2, a_3, B_0, B_1, B_2, B_3, and B_4 are constants for specific research area.

$$\begin{cases} f_1(p_p, I_p, \sigma_v) = 0 \\ f_2(p_c, I_p, \sigma_v) = 0 \\ f_3(p_f, I_p, \sigma_v) = 0 \end{cases} \tag{8}$$

where p_c and p_f are collapse and fracture pressures for drilling.

2.7. Procedure of Seismic Impedance Inversion

Based on logging data such as acoustic and density, acoustic wave velocity and density were calculated for each formation layer. Seismic wave data were then used to predict the rock properties, geologic structures, and petrophysical properties [26]. Based on the seismic wavelet properties extraction, the logging was firstly correlated to them using Seismic MEME Inversion (SMI, version 3.0) package. From seismic data, the horizons were calibrated by the depth based on the velocity model. Then, the initial model was constructed from the wavelet extraction and the horizon calibration. From the inversion iteration, the post-stack seismic data was then transformed into seismic impedance. Lastly, the P-wave velocity and the density were both correlated to the seismic impedance. This workflow is illustrated in Figure 2.

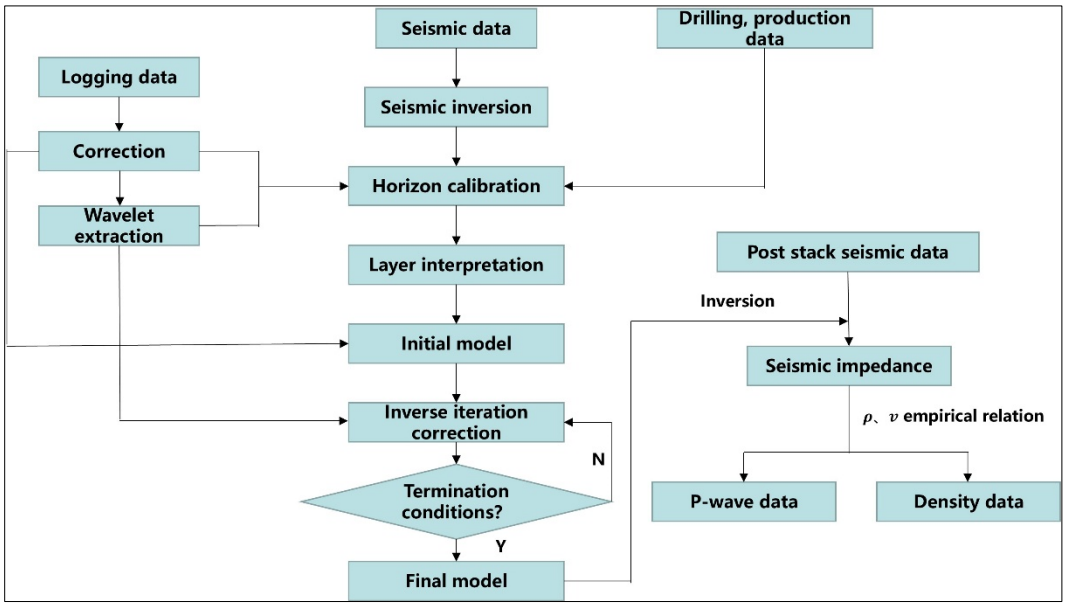


Figure 2. The workflow for seismic impedance inversion.

3. Field Application

In Figure 3, the Hutubi tectonic zone was selected for modelling seismic impedance and pre-drilling prediction of wellbore stability. There were limited exploration wells in this zone, such as Hu−102, Hu−103, and Hutan−1 wells, along with an adjacent planned well Huqian−1. Seismic data from the local tectonic zone were utilized to construct the impedance model following the aforementioned method.

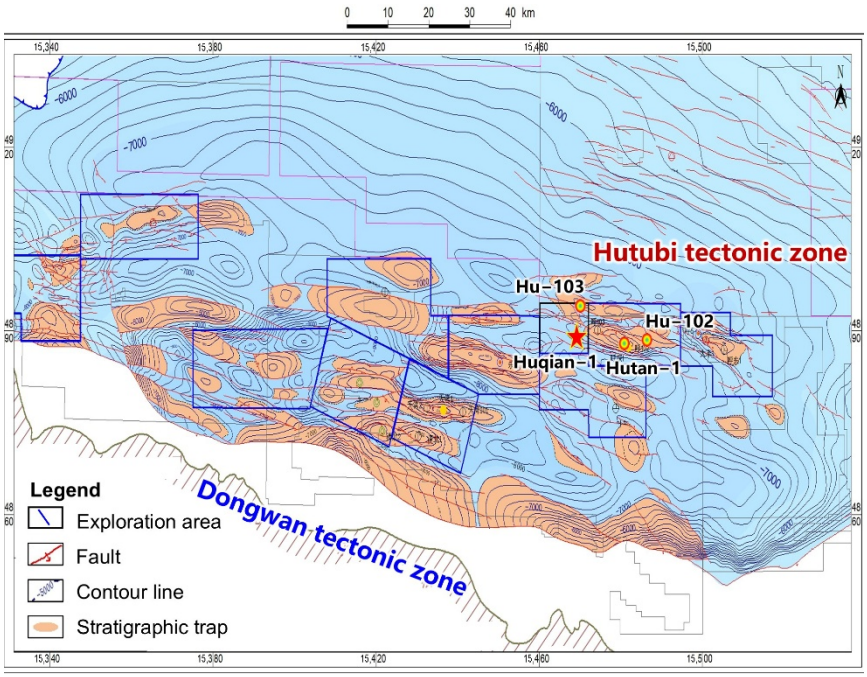


Figure 3. Ultra-deep wells of the Hutubi tectonic zone of the south margin, Junggar Basin.

The layering models of relationships between seismic velocity and logging data of the whole formation layers were constructed using seismic attributes and the corresponding acoustic logging data. Then, the acoustic logging data, or interval transit time of ten corresponding formations were predicted using layering models seismic data. The predicted

logging data of the eight intervals were composed together to generate the acoustic logging trace ranging from 0 m to 7950 m in depth, as shown in Figure 4.

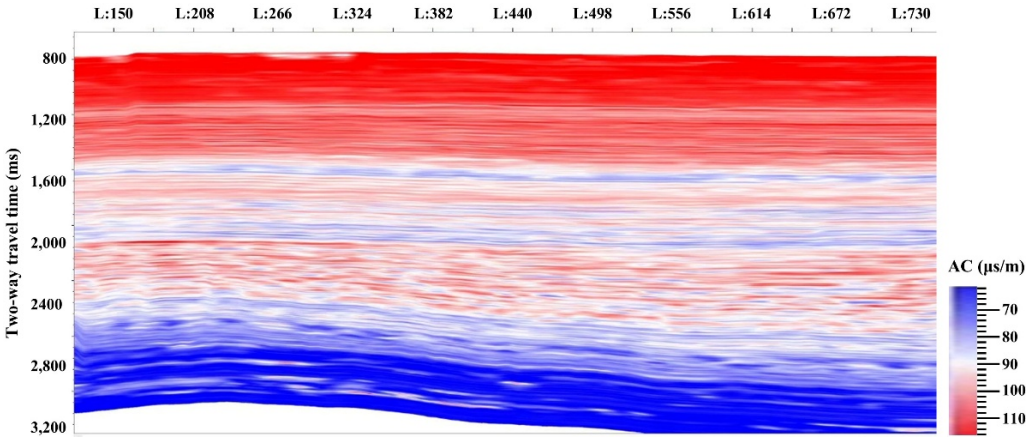


Figure 4. The sonic interval transit time (p-wave) within the Hutubi area.

The density logging trace could be predicted by using the same method as shown in Figure 5. The density logging data of other formations can be derived from the predicted sonic logging data (i.e., interval transit time) based on the empirical relationship. Figure 6 shows the three-dimensional pore-pressure prediction results for this area.

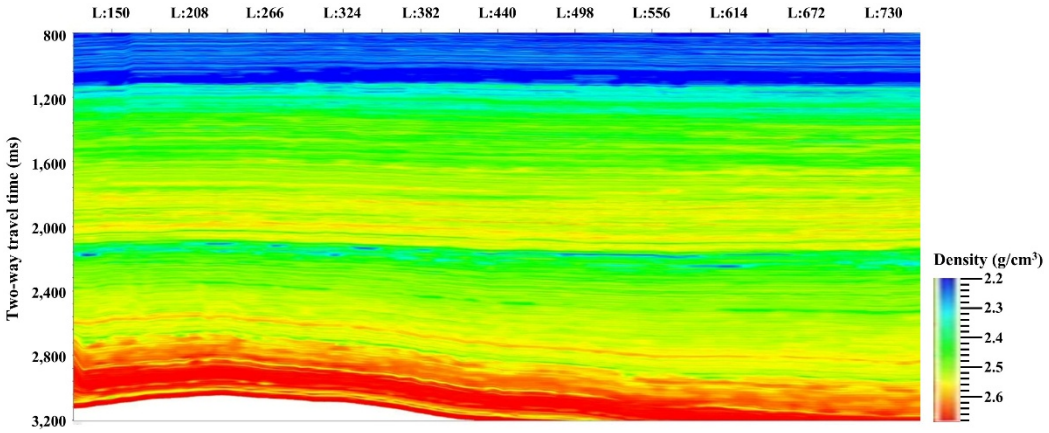


Figure 5. The density body of the Hutubi area.

Figure 7 and Table 1 show the predicted three pressures for the well Hutan-1. From the deviation comparison of the P-wave acoustic transit time and the normal compact trend line (NCTL), it demonstrates two abnormal highly pressurized sections such as Taxihe Group (N_1t) and Anjihaihe group ($E_{2-3}a$), whose pore-pressure gradients reach 1.38 g/cm^3 and 1.5 g/cm^3, respectively. In these two sections, the corresponding mud density windows become narrower than the normal pressurized formations. The downhole measurement of pore pressure at 7300 m is 2.02 g/cm^3, which is comparable to the prediction of 2.04 g/cm^3, with a relative error of less than 1%. This shows great potential of pore-pressure prediction using the seismic inversion method. Due to the limited chance of downhole measurement of pore pressures, there are no additional measurements of pore pressures.

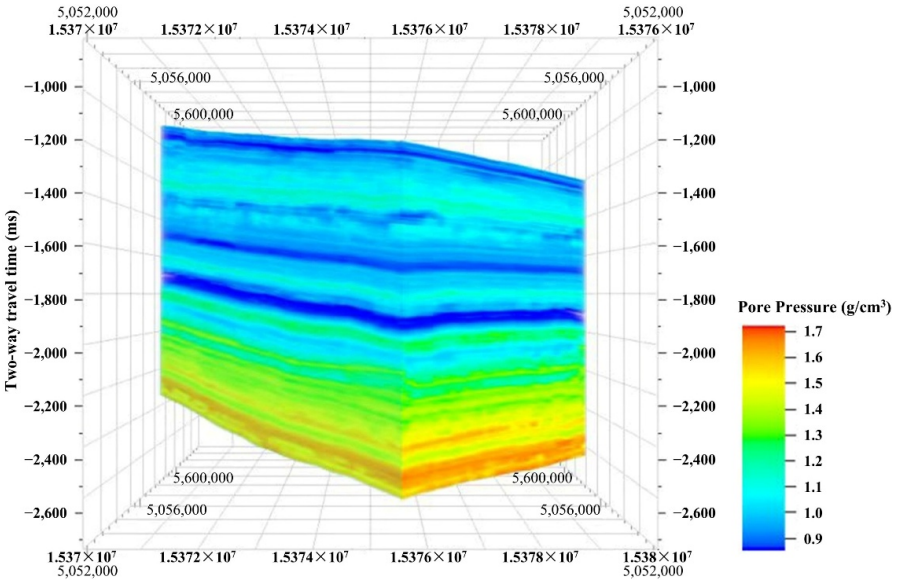


Figure 6. The three-dimensional pore-pressure predicted results of the Hutubi area.

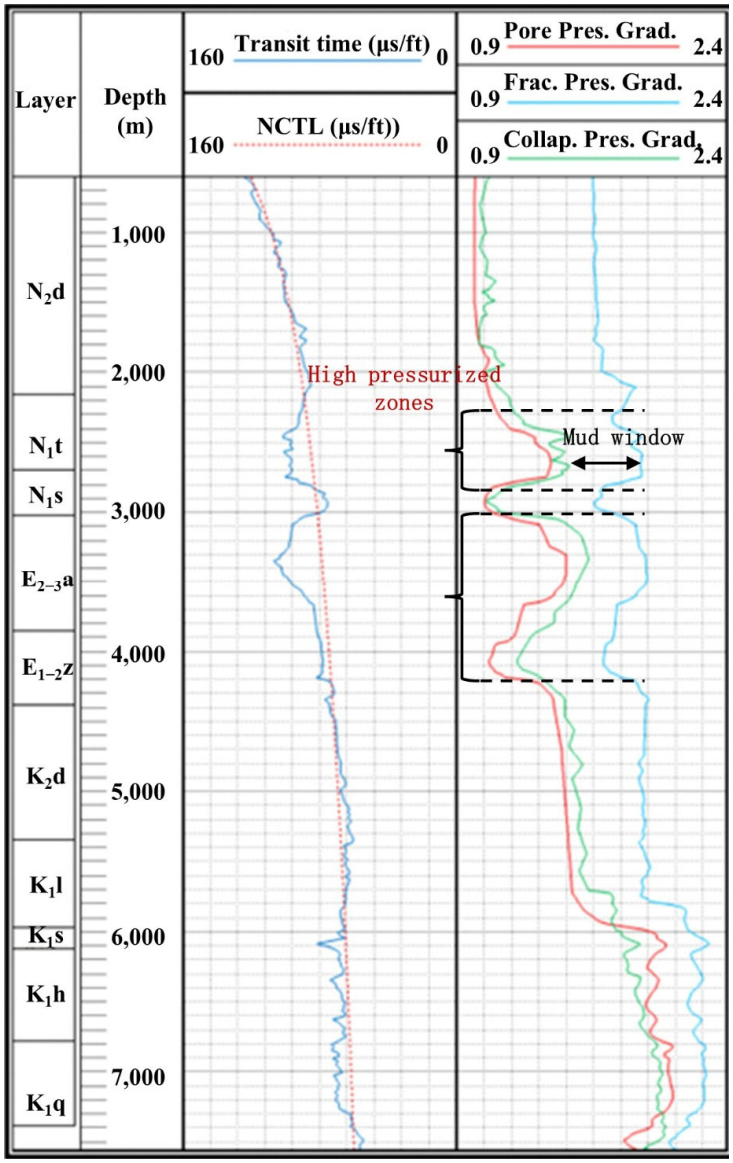


Figure 7. The predicted three-pressures profiles for Well Hutan−1.

Table 1. The predicted three-pressure data of the well Hutan−1.

Formation	Bottom Vertical Depth (m)	Pore-Pressure Gradient (g/cm^3)	Collapse Pressure Gradient (g/cm^3)	Fracture Pressure Gradient (g/cm^3)
Dushanzi Group-N_2d	0~2450	0.99~1.00	1.64~1.87	1.12~1.35
Taxihe Group-N_1t	2450~2970	1.00~1.38	1.75~1.92	1.35~1.53
Shawan Group-N_1s	2970~3240	1.00~1.37	1.65~1.91	1.53
Anjihaihe Group-$E_{2-3}a$	3240~3985	1.02~1.50	1.76~1.95	1.30~1.85
Ziniquanzi Group-$E_{1-2}z$	3985~4630	1.02~1.50	1.70~1.95	1.30~1.70
Donggou Group-K_2d	4630~5700	1.49~1.50	1.90~1.94	1.70~1.75
Lianmuqin Group-K_1l	5700~6255	1.50~1.92	1.90~2.16	1.73~2.15
Shengjinkou Group-K_1s	6255~6470	1.87~2.00	2.17~2.28	2.13~2.14
Hutubi Group-K_1h	6470~7150	1.90~2.01	2.16~2.25	2.14~2.18
Qingshuihe Group-K_1q	7150~7770	1.93~2.07	2.16~2.27	2.08~2.18

Figure 8 and Table 2 show the predicted three pressures for the well Huqian-1. From the deviation between P-wave acoustic transit time and the NCTL, it demonstrates two abnormal highly pressurized sections such as Taxihe Group (N_1t) and Anjihaihe group ($E_{2-3}a$), whose pore-pressure gradients reach 1.38 g/cm^3 and 1.5 g/cm^3, respectively. In these two sections, the corresponding mud density windows become narrower than the normal pressurized formations. This indicates that they are the most unsafe drilling depth sections for the well Huqian-1. The above practical application shows that the prediction model proposed in this paper is effective and feasible for practical drilling activities.

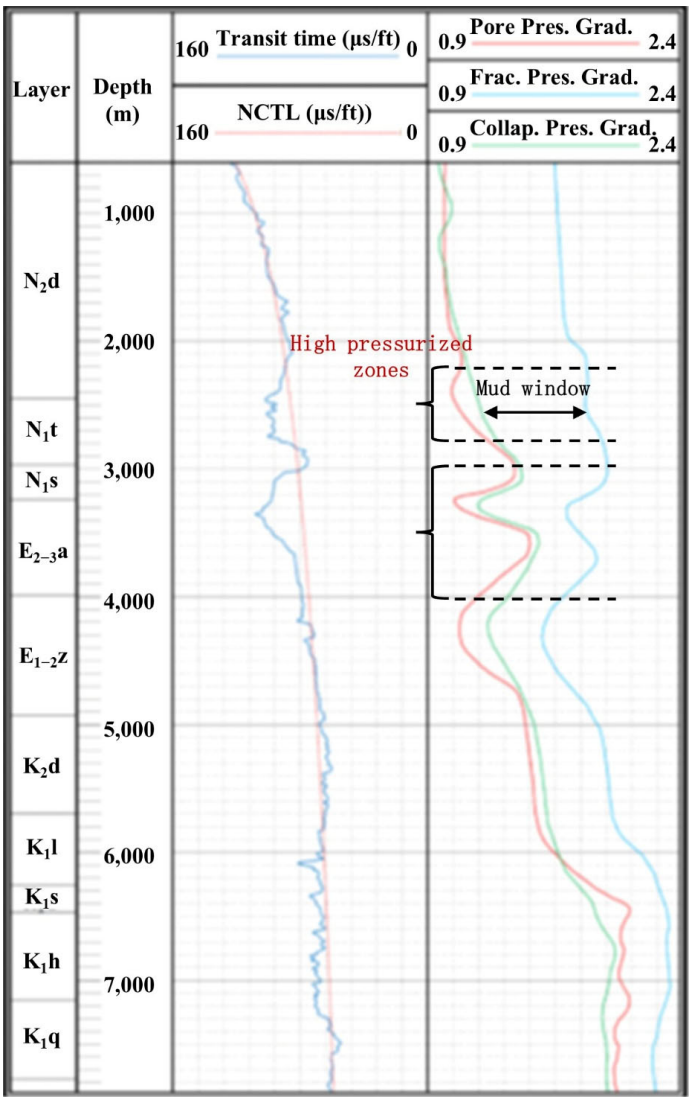


Figure 8. The predicted three-pressure profiles of the well Huqian−1.

Table 2. The predicted three-pressure data of the well Huqian−1.

Formation	Bottom Vertical Depth (m)	Pore-Pressure Gradient (g/cm^3)	Collapse Pressure Gradient (g/cm^3)	Fracture Pressure Gradient (g/cm^3)
Dushanzi Group-N_2d	0~2450	0.99~1.00	1.00~1.19	1.64~1.87
Taxihe Group-N_1t	2450~2970	1.00~1.38	1.18~1.52	1.75~1.92
Shawan Group-N_1s	2970~3240	1.00~1.37	1.06~1.48	1.65~1.91
Anjihaihe Group-$E_{2-3}a$	3240~3985	1.02~1.50	1.31~1.71	1.76~1.95
Ziniquanzi Group-$E_{1-2}z$	3985~4630	1.02~1.50	1.31~1.52	1.70~1.95
Donggou Group-K_2d	4630~5700	1.49~1.50	1.48~1.75	1.90~1.94
Lianmuqin Group-K_1l	5700~6255	1.50~1.92	1.62~1.78	1.90~2.16
Shengjinkou Group-K_1s	6255~6470	1.87~2.05	1.78~1.92	2.17~2.25
Hutubi Group-K_1h	6470~7150	1.90~2.05	1.81~1.98	2.16~2.30
Qingshuihe Group-K_1q	7150~7770	1.93~2.03	1.97~2.00	2.16~2.25

4. Conclusions

(1) Based on seismic inversion, borehole stability could be evaluated by constructing the relationship between three pressures and seismic velocity. The input data include seismic, logging, and geological information, which together could realize real-time prediction of acoustic and density log data of undrilled formations.

(2) In the ultra-deep well Huqian−1, two abnormal highly pressurized sections are confirmed as Taxihe and Anjihaihe groups, which conforms to the practical drilling activities. The preliminary results demonstrate that the relationship between three pressures and seismic velocity is effective for the Hutubi area.

(3) This model is applicable to P-wave real-time prediction of borehole stability within the scope of multiple wells in the same geological block. The precision of the prediction is satisfactory for the real-time operation requirements for local drilling.

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Data Availability Statement: The original contributions presented in this study are included in the article. Further inquiries can be directed to the corresponding author.

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could be construed as a potential conflict of interest. The companies had no role in the design of the study; in the collection, analyses, or interpretation of data; in the writing of the manuscript, or in the decision to publish the results.

References

1. Hou, B.; Zeng, C.; Chen, D.; Fan, M.; Chen, M. Prediction of Wellbore Stability in Conglomerate Formation Using Discrete Element Method. *Arab. J. Sci. Eng.* **2017**, *42*, 1609–1619. [CrossRef]
2. Hou, B.; Xie, S.; Chen, M.; Jiang, G.; Jin, Y.; Liang, C. New Method of Layered Drilling Fluid Design to Overcome Wellbore Instability of Piedmont Structures. *Adv. Mater. Res.* **2012**, *524–527*, 1480–1483. [CrossRef]
3. Wu, C.; Liu, J.; Zhang, D.; Chen, X.; Zhao, W. A Prediction of Borehole Stability While Drilling Preliminary Prospecting Wells Based on Seismic Impedance. *Pet. Explor. Dev.* **2015**, *42*, 427–433. [CrossRef]
4. Jin, Y.; Chen, M.; Zhang, X. Study on Prediction for Borehole Stability before Drilling. *Acta Pet. Sin.* **2001**, *22*, 96–99. [CrossRef]
5. Jin, Y.; Chen, M.; Yang, X. Prediction of Safe Mud Density Window by Interval Velocity before Drilling. *Yanshilixue Yu Gongcheng Xuebao/Chin. J. Rock Mech. Eng.* **2004**, *23*, 2430–2433. [CrossRef]
6. Yang, J.; Yin, C.; Dai, R.; Yang, S.; Zhang, F. Seismic Impedance Inversion via L0 Gradient Minimisation. *Explor. Geophys.* **2019**, *50*, 575–582. [CrossRef]
7. Wu, C.; Chen, M.; Jin, Y. Real-Time Prediction Method of Borehole Stability. *Pet. Explor. Dev.* **2008**, *35*, 80–84. [CrossRef]
8. Wu, C.; Liu, J.H.; Zhang, D.Q.; Wang, L. Predicting Borehole Stability While Drilling Based on Nonlinear Inversion. *Yantu Gongcheng Xuebao/Chin. J. Geotech. Eng.* **2015**, *37*, 1810–1817. [CrossRef]
9. Bloch, M.; Gupta, A. A New Strategy for near Real-Time Prediction of Borehole Stability. *J. Can. Pet. Technol.* **2001**, *40*. [CrossRef]
10. Ji, D.; Xu, Y.; Pang, Z.; Yuan, B.; Zhao, K. Classification of Typical Tectonic Styles and Exploration of Hydrocarbon Accumulation Patterns in Southern Junggar Basin, China. *Energies* **2022**, *15*, 6715. [CrossRef]
11. Jin, Y.; Chen, M. Prediction of Borehole Stability by Seismic Records. *Shiyou Xuebao/Acta Pet. Sin.* **2004**, *25*, 89–92. [CrossRef]
12. Xiao, Y.; Hurich, C.; Butt, S.D. Assessment of Rock-Bit Interaction and Drilling Performance Using Elastic Waves Propagated by the Drilling System. *Int. J. Rock Mech. Min. Sci.* **2018**, *105*, 11–21. [CrossRef]
13. Xiao, Y.; Hurich, C.; Butt, S.D. Characterization of Rotary-Percussion Drilling as a Seismic-While-Drilling Source. *J. Appl. Geophys.* **2018**, *151*, 142–156. [CrossRef]
14. Wu, C.; Chen, M.; Jin, Y. Pre-Drilling Prediction of Wellbore Stability Using Seismic Inversion Technology. *Oil Drill. Prod. Technol* **2006**, *2*, 18–20, 82. [CrossRef]
15. Sun, X.K.; Feng, S.M. Wavelet Extraction Methods in Seismic Inversion System. *Comput. Tech. Geophys. Geochem. Explor.* **2010**, *32*, 120–125, 107. Available online: https://en.cnki.com.cn/Article_en/CJFDTOTAL-WTHT201002003.htm (accessed on 6 May 2010).
16. Pranowo, W. Time-Varying Wavelet Estimation and Its Applications in Deconvolution and Seismic Inversion. *J. Pet. Explor. Prod. Technol.* **2019**, *9*, 2583–2590. [CrossRef]
17. Hu, Y.; Yu, X.H.; Li, S.L.; Chen, G.Y.; Zhou, Y.L.; Gao, Z.P. Improving the Accuracy of Geological Model by Using Seismic Forward and Inversion Techniques. *Pet. Explor. Dev.* **2014**, *41*, 208–216. [CrossRef]
18. Wu, C.; Chen, M.; Jin, Y. Predicting Borehole Stability before Drilling Using Seismic Attributes. *Pet. Drill. Tech.* **2006**, *34*, 35–37. Available online: https://en.cnki.com.cn/Article_en/CJFDTOTAL-SYZT200603018.htm (accessed on 25 May 2006).
19. Luo, H.Z.; Ji, Y.X.; Wang, X.L.; Wang, X.M. Making P-SV Shear Wave Synthetic Seismic Record. *Zhongguo Shiyou Daxue Xuebao (Ziran Kexue Ban)/J. China Univ. Pet. (Ed. Nat. Sci.)* **2010**, *34*, 37–40, 45. Available online: https://zkjournal.upc.edu.cn/zgsydxxben/article/abstract/20100108 (accessed on 20 February 2010).
20. Xiyuan, L.; Wangshui, H.; Nan, Z.; Heng, Z.; Xuan, L. Synthetic Seismic Recording Method by the Continuous Wavelet-Reflection Superposition. *Pet. Geol. Oilfield Dev. Daqing* **2020**, *39*, 133–138. [CrossRef]
21. Li, Q.Z. On Strategy of Seismic Restricted Inversion. *Pet. Geophys. Prospect.* **1998**, *4*, 423–438, 572. [CrossRef]
22. Treitel, S.; Lines, L. Past, Present, and Future of Geophysical Inversion: A New Millennium Analysis. *Geophysics* **2012**, *66*, 21–24. [CrossRef]
23. Wen, X.; Yang, J.; Li, L.; He, J.; Li, B. Low-Frequency Sparse Double-Constrained Broadband Seismic Impedance Inversion. *Nat. Gas Ind. B* **2019**, *6*, 556–563. [CrossRef]
24. Yang, Y.Q.; Guo, H.L.; Hui, C.; Li, W.D.; Jin, C.G.; Zhuo, X.U. Cross-Well Seismic Constrained Acoustic Impedance Inversion. *J. Jilin Univ. (Earth Sci. Ed.)* **2006**, *36*, 468–473. Available online: http://xuebao.jlu.edu.cn/dxb/EN/abstract/abstract8492.shtml (accessed on 6 May 2006).

25. Fan, H.; Zhang, C. Determination and Regression of Overburden Pressure Gradient. *Pet. Drill. Technol.* **2002**, *3*, 6–8. [CrossRef]
26. Li, Z.; Pan, Y. Stability Analysis of Wellbore with Permeation. *Eng. Mech.* **2002**, *19*, 105–108. Available online: https://en.cnki.com.cn/Article_en/CJFDTOTAL-GCLX200203020.htm (accessed on 1 June 2002).

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