ABSTRACTS

High resolution Radon transform based on SL_0 and its application in data reconstruction. Xue Yaru[1], Wang Min[1] and Chen Xiaohong[1]. OGP, 2018, 53(1): 1-7.

The L_0 norm is the optimal way to measure the sparsity of data, however it is difficult to solve the L_0 due to its non convexity. This paper introduce smoothed L_0 norm (SL_0) into the Radon transform to overcome the difficulty of solving and further to improve the resolution of Radon transform. We first use smoothed continuous functions as objective functions of the parabolic Radon transform to approximate the L_0 norm, and then we use the steepest descent method and gradient projection principle to approach the optimal solution. Experiments on both theoretical model and field data show that the proposed method not only improves the resolution of Radon transform, but also restores the continuity of seismic data and AVO characteristics.

Keywords: smoothed L_0 norm (SL_0), Radon transform, sparse constraint, data reconstruction

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An improved neural-network cascade-correlation algorithm and its application in seismic first break picking. Song Jianguo[1], Li Fuzhen[2], Xu Weixiu[3] and Li Zhe[1]. OGP, 2018, 53(1): 8-16.

To overcome existing problems of BP neural network, we introduce the cascade-correlation algorithm into the neural network construction. The proposed algorithm has a faster convergence than BP algorithm, and it can decide its own network architecture based on problems to be solved. That means it can expand network topology to learn new samples. The initial network of the standard cascade-correlation algorithm has only an input layer and an output layer, while the improved algorithm starts with an appropriate BP network architecture (including hidden layers). In addition, in order to prevent weight-ill growth, a regularization term is added to objective functions in candidate hidden units training to decay weights. Simulation experiments demonstrate that the improved cascade-correlation algorithm has faster convergence and stronger generalization ability. Cross-plots of five attributes such as instantaneous-intensity ratio, amplitude, frequency, curve-length ratio, and adjacent-trace correlation, show that first breaks peaked by the proposed algorithm can be easily and reliably discriminated. The proposed algorithm achieves good performance in the first break picking on real data.

Keywords: first break picking, first arrival, cascade-correlation algorithm, Quickprop algorithm, seismic attribute

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Frequency dispersion analysis of MASW in real seismic data. Jiang Fuhao[1], Li Peiming[1], Zhang Yimeng[1], Yan Zhihui[1] and Dong Lieqian[1]. OGP, 2018, 53(1): 17-24, 46.

Usually surface inversion is performed with the high-frequency surface wave acquired with small trace interval at short spreads. Near-surface structure inversion is also conducted with surface waves from surface seismic data. Real seismic data decrease the accuracy of frequency dispersion curve during the surface wave inversion due to data complexity, which will affect the results of near-surface structure inversion. In this paper, the authors make a detailed analysis about some difficulties of frequency dispersion analysis during the multi-trace analysis of surface wave (MASW), for example, how to determine the minimum offset and the quantity of seismic traces used for frequency dispersion analysis, and how to process strong surface waves and weak surface waves on the same shot data. At the same time, some discussions are made about frequency dispersion curve accuracy improvement. Analysis results on real data prove that our method is effective and can achieve favorable near-surface structure inversion results.

Keywords: surface wave, inversion, near-surface structure, frequency dispersion analysis, seismic data

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Fast and stable Rayleigh-wave dispersion-curve inversion based on particle swarm optimization. Cai Wei[1], Song Xianhai[1,2], Yuan Shichuan[1] and Hu Ying[1]. OGP, 2018, 53(1): 25-34.

Rayleigh-wave dispersion-curve inversion can effectively obtain shear wave velocity and formation thickness. However, Rayleigh-wave dispersion-curve inversion based on local linearization cannot adapt to inversion objective function characteristics

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such as non-linear, multi-parameters, and multi-extremums. To overcome this issue, we propose a new Rayleigh-wave dispersion-curve inversion based on a particle swarm optimization (PSO) algorithm for global optimization. We first invert synthetic data with noise and without noise of three theoretical models, and verify the effectiveness and stability of the PSO inversion of Rayleigh wave data. Then we compare PSO with simulated annealing (SA), and find that PSO has faster convergence and higher accuracy than SA. Finally, we apply this method into field seismic data from Wyoming in the United States to test its applicability. Theoretical and real data tests show that the proposed method can be used for the quantitative interpretation.

Keywords: Rayleigh wave, dispersion-curve inversion, particle swarm optimization (PSO), simulated annealing (SA)

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Traveltime calculation based on linear interpolation in hybrid meshes for rugged topographical conditions. Wang Qi[1], Zhu Pan[1], Ye Pei[2], Li Qin[3] and Li Qingchun[1]. OGP, 2018, 53(1): 35-46.

In order to improve the accuracy and efficiency of traveltimes calculation under complex structures with rugged topographical conditions, we propose a new LTI method based on hybrid meshes. In rectangle meshes and irregular quadrilateral meshes, we deduce new formulas for local travetime calculation in hybrid meshes based on formulas only for local traveltime calculation in rectangle meshes. The formulas are proved by the tests. Then, we promote this new method into multi-stage LTI method in hybrid meshes. Numerical test results show that the proposed method can achieve accurate traveltimes and raypaths in the sharply rugged topography and complex near-surface.

Keywords: traveltime linear interpolation, hybrid mesh, rugged topography, multiples, converted wave

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Acoustic equation high-accuracy modeling in the frequency domain based on MCPML absorbing boundary. Dong Shiqi[1], Han Liguo[1], Hu Yong[1] and Luo Yuqin[1]. OGP, 2018, 53(1): 47-54.

The 9-point scheme for the second-order accuracy of the hybrid grid cannot meet the actual needs of acoustic equation modeling in the frequency domain because of the complex structure of the underground medium. A fourth-order 17-point difference scheme based on the 9-point with fourth-order differential accuracy is derived, and a nonsplit multi-axial convolution perfectly matched layer (MCPML) absorbing boundary is applied. Compared with conventional perfectly matched layer (PML) absorbing boundary, MCPML combines the advantages of convolution perfectly matched layer (CPML) absorbing boundary and multi-axial perfectly matched layer (MPML) absorbing boundary to improve the absorption of wave field with large incident angle without increasing computational burden. Meanwhile, the non-split method is easy to program. The proposed method is applied to the Marmousi model and its effectiveness is verified.

Keywords: frequency domain, acoustic equation, 17-point difference scheme, multi-axial convolution perfectly matched layer (MCPML) absorbing boundary

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Seismic wave modeling based on modified symplectic scheme and quasi-particles method. Su Bo[1,3], Tuo Xianguo[2] and Liu Zhigui[3]. OGP, 2018, 53(1): 55-62.

Based on Hamilton mechanics, we develop a quasi-particles system to discretize seismic wave equation from the viewpoint of molecular dynamics. Each particle in the system only interacts with the particles which located at the upper, the lower, the left, and the right, and the four diagonal particles. The force and the relative displacement between the particles can be considered as approximately linear. In this paper, the interaction coefficients of the particles are derived. We get a modified symplectic scheme with third-order on the basis of two-order symplectic schemes to deal with temporal discretization. Theoretical analysis shows the new scheme possesses weaker numerical dispersion and larger stability than those of the conventional symplectic schemes. The modified symplectic scheme is suitable for long-term computational owing to all positive symplectic coefficients which consistent with iterative computation. In order to test the accuracy of the symplectic scheme and the spatial quasi-particles system, we adopt Lamb's problem

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to investigate the accuracy and efficiency of the numerical simulation of elastic wave. In addition, the Sigsbee2B velocity model is selected to test the stability of the proposed method. Numerical experiments demonstrate improvements in the numerical dispersion suppression and numerical stability of the modified symplectic scheme.

Keywords: seismic wave modeling, molecular dynamics, quasi-particles system, modified symplectic scheme

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Seismic multi-wave traveltime tomography in 3D TI media. Huang Guojiao[1], Sun Jiangbing[2], Bai Chaoying[3] and Qian Wei[1]. OGP, 2018, 53(1): 63-72.

The conventional anisotropic tomography is based on a weak anisotropy assumption, mainly uses the traveltime to carry out linear inversion and ignores the lateral changes in the media, so inversion results are usually not reliable. Therefore, we study a multi-wave traveltime tomography in 3D TI media. The multi-step irregular shortest path method in isotropic media is extended to 3D TI media to trace multi-wave (reflected wave, transmitted wave, and converted wave) arrivals, and the algorithm for inversion in isotropic media is used. Incorporating with the equation for phase and group velocity derivatives, 5 anisotropic elastic parameters are inverted simultaneously by multi-wave traveltimes. This method does not assume that medium is weakly anisotropic whether in ray tracing and traveltime calculation, or in an inversion equation establishment, or in Jacobian matrix calculation. What is more, ray paths and traveltimes are re-tracked at each iteration, and Jacobian matrix elements are updated. So this method is suitable for multi-wave traveltime tomography in 3D TI media. Numerical test results indicate that the proposed method can improve the imaging spatial resolution.

Keywords: TI media, multi-wave traveltime, elastic parameter inversion, traveltime tomography

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3D adaptive least-squares reverse-time migration. Kuang Bin[1], Tang Xianggong[1], Zhang Meng[1], Zhao Qingguo[1] and Shan Lianyu[1]. OGP, 2018, 53(1): 73-79.

We propose an adaptive least-squares reverse-time migration to address practical issues in least-squares reverse time migration. These problems include unknown source wavelet, inaccurate migration velocity, massive computation, etc. The adaptive approach involves dynamic time warping, reverse-time migration (RTM) amplitude gain, adaptive weighting factor, and migration aperture control associated with imaging. This approach can correct the mismatching between synthetic and real data in waveform and energy, realize adaptive controlled migration aperture, and solve problems such as imperfect migration velocity, slow convergence, and migration artifacts in gradient computation. Test results on field data in the Block Y indicate that the proposed approach deserves lithologic exploration in the Eastern China.

Keywords: adaptive least-squares reverse-time migration, dynamic time warping, RMS amplitude gain, adaptive weighting factor, aperture calculation

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Turning wave false image removal based on wavelength-dependent smoothing operator in reverse time migration. Tang Yongjie[1,2], Song Guiqiao[3], Liu Shaoyong[1,2], Gu Hanming[1,2] and Yan Zhe[1,2]. OGP, 2018, 53(1): 80-86.

The conventional reverse time migration (RTM) based on cross-correlation imaging conditions not only produces low-frequency artifacts, but also generates the false images of turning wave in the strong velocity gradient regions, and the false images cannot be removed by a simple Laplacian filter. In this paper, we introduce the imaging condition by separating up-going and down-going wavefields to analyze the causes of the false images in RTM and it does indicate that the false images of turning wave are generated by the cross-correlation of the up-going source and down-going receiver wavefields in the strong velocity gradient areas. In order to eliminate the false images and take into account the computational efficiency, we propose a false image removal method based on the wavelength-dependent smoothing operator. This method includes the wavelength effect which makes the propagation characteristics of wavefields in the strong velocity gradient areas more close to the propagation characteristics in the true velocity. Numerical experiments demonstrate that the proposed wavelength-dependent smoothing algorithm can

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suppress the turning wave false images and perform RTM efficiently under the classical imaging framework.

Keywords: reverse time migration (RTM), cross-correlation, turning-wave false image, wavelength-dependent smoothing

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Visco-acoustic wave full waveform inversion in the 2D time domain. Li Haishan[1,2], Yang Wuyang[1,2] and Yong Xueshan[1,2]. OGP, 2018, 53(1): 87-94.

Real earth media are characterized by the visco-elasticity, so it is necessary to consider the absorption and attenuation effects in the full waveform inversion. In this paper, we propose a visco-acoustic wave full waveform inversion in the 2D time-domain. According to the visco-elastic wave equation based on generalized standard linear solid (GSLS) model, a first-order velocity-stress visco-acoustic wave equation is obtained. Then the corresponding P-wave velocity gradient is derived. Based on high-order staggered-grid finite-difference method and conjugate gradient method, the visco-acoustic full waveform inversion in the 2D time domain based on first-order velocity-stress visco-acoustic wave equation is realized. Numerical examples demonstrate the effectiveness of the proposed method. Compared with other methods without considering the absorption and attenuation effects, the P-wave velocity inversion results with the proposed method are much more accurate.

Keywords: visco-elastic medium, generalized standard linear solid, visco-acoustic wave equation, conjugate gradient, full waveform inversion

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Full waveform inversion based on principal component analysis and gradient reconstruction. Shi Caiwang[1,2,3] and He Bingshou[1,2,3]. OGP, 2018, 53(1): 95-104.

When applied to heavily noisy data, full waveform inversion (FWI) usually provides a terrible result because conventional FWI concentrates on complete consistency between simulated data and original records. This article analyzes the influence of random noise on FWI and proposes a new gradient processing method based on principal component analysis (PCA) and gradient reconstruction. Firstly we apply PCA to the matrix consisted of every shot gradient, and pick specific principal components with high representativeness. Then we can reconstruct gradient with these principal components. When the signal-to-noise ratio (SNR) of residuals is relatively high, this method can reconstruct accurate gradient which will help the objective function decrease effectively. If the SNR is low, the reconstructed gradient will prevent the inversion process from accessing to a wrong model, which can provide a more reasonable initial model for the next frequency band. Numerical experiments show that FWI based on PCA and gradient reconstruction is more robust than conventional methods, which obtains acceptable results even when the SNR is low.

Keywords: full waveform inversion, random noise, principal component analysis, gradient reconstruction

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A method of 1D mesoscopic digital rock physics in the frequency domain. Wu Jianlu[1,2] and Wu Guochen[1,2]. OGP, 2018, 53(1): 105-112.

The attenuation and dispersion of seismic wave in seismic frequency band are mostly induced by mesoscopic heterogeneity because of the fluid flow of different scales in the porous medium when the seismic wave propagates in saturated media. We build a 1D digital physical model with two kinds of the wave equations in porous medium, and calculate the attenuation and dispersion of the 1D physical model with the finite-difference method in the frequency domain. We test and verify the accuracy of the method presented in the context by the model of porous layers alternately saturated with water and gas. In this paper, the characteristic elements are shown to be effective by calculating models containing different amounts of characteristic elements. Then we analyze the results of different heterogeneous scales and combination cases of the layers saturated water and gas in the condition of the same gas saturation. Finally the results for the 1D porous media alternately saturating three kinds of fluid indicate that the wave-induced fluid flow in mesoscopic heterogeneities mostly causes the at-

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tenuation and dispersion in the seismic frequency band.

Keywords: seismic wave attenuation, dispersion, porous medium, finite difference

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A modified Kuster-Toksöz rock physics model and its application. Liu Zhishui[1,2,3], Sun Zandong[2,4], Dong Ning[3], Liu Junzhou[3], Liu Zhixiu[5] and Wang Yajing[4]. OGP, 2018, 53(1): 113-121.

Kuster-Toksöz (KT) rock physics model is a classical rock physics model concerning the influence of multiple-inclusion material (void inclusion, fluid and solid inclusions) on elastic wave velocities. However, the KT model is limited to dilute concentration of inclusion material. In this paper, the ideal of differential effective medium is applied into the KT model, and a new modified KT rock physics model for rock containing high-concentration inclusions is derived. This rock physics model is applied to organic-enriched rocks. Firstly, the simulation result shows that the new model is superior to the KT model in rocks with high volume inclusion material. Furthermore S-wave velocity prediction based on the proposed method is more accurate than those from the KT model.

Keywords: velocity prediction, Kuster-Toksöz model, differential effective medium, inclusion material, kerogen, pore, organic enriched rock

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Volcanic lithology and reservoir identification based elastic wave characteristics analysis in Yingcheng Formation, Xujiaweizi Depression. Dai Shili[1]. OGP, 2018, 53(1): 122-128.

Volcanics are characterized by different types of lithology and strong heterogeneity, therefore volcanic lithology and reservoir identification are very difficult. We propose in this paper an approach to predict volcanic lithology and reservoirs in Yingcheng Formation, Xujiaweizi Depression based on elastic wave characteristics analysis. First we analyze changes of P- and S-wave velocity in different lithologic rocks with different fluids to provide accurate S-wave curves. Then we introduce "lithology group" in rock physics study for complicated volcanic lithology. We use three parameters such as S-wave velocity, density, and lambda to divide Yingcheng Formation lithology into four rock groups, namely, mudstone, basalt (basalt, basaltic andesite), andesite (andesite, trachyte, dacite), and rhyolite (rhyolite, tuff, conglomerate, volcanic breccia). Finally we analyze reservoir and gas sensitive elastic parameters in different lithological groups. It is found that oil reservoirs show low-density characteristics while gas-bearing beds have low-Poisson's ratio characteristics. The proposed approach is successfully applied to identify volcanic lithology, oil reservoirs, and gas-bearing beds in Xujiaweizi Depression, which lays a solid foundation for the accurate volcanic reservoir prediction.

Keywords: lithologic reservoir identification, volcanic, rock physical parameter, Songliao Basin, Yingcheng Formation

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Three term AVO approximation of K_f-f_m-ρ and prestack seismic inversion for deep reservoirs. Yin Xingyao[1], Wang Huixin[1,2], Cao Danping[1], Zhou Qijie[1] and Guo Shuwen[3]. OGP, 2018, 53(1): 129-135.

With deeply buried targets, information of large incident angles is deficient. Conventional fluid factors are not sensitive enough to discriminate fluid in reservoirs due to the deep compaction. So a more sensitive fluid indicator aiming at small incident angle is needed to be built for deep reservoir. With the characteristics of rock physics, we derive a new three term AVO approximation in terms of pore-fluid bulk modulus K_f, which is more sensitive to hydrocarbon, dry rock matrix term f_m, and density ρ. The accuracy of the new approximation is almost equivalent to exact Zoeppritz equation. Consequently the new approximation can meet the requirements of inversion. In addition, tests on synthetic data show that the pore-fluid bulk modulus K_f can be reliably estimated from the prestack seismic data. We built a flow path of extracting pore-fluid bulk modulus K_f by elastic impedance inversion for deep reservoirs with small incident angles. And the proposed method is proved to be accuracy, reliable and feasible after real data tests.

Keywords: deep reservoir, three term AVO approximation, fluid identification

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Quality factor *Q* estimation based on time-varying wavelet. Feng Wei[1], Hu Tianyue[1], Chang Dingyue[1], Cui Yongfu[2] and Peng Gengxin[2]. OGP, 2018, 53(1): 136-146.

The stratigraphic filtering and viscoelasticity attenuation can cause narrower seismic frequency band, lower dominant frequency, and phase distortion. The *Q* estimation and inverse *Q* filtering are important tools for attenuation compensation and resolution improvement. We propose a *Q* estimation methods for surface seismic datasets. The propagating wavelet is subject to stratigraphic filtering, viscoelastic attenuation, and concomitant dispersion, which causing time-varying characteristics. Firstly, the nonstationary seismic forward modeling is achieved in the time domain by wavelet convolve matrix, which shows the time-varying characteristics of propagating wavelet. Secondly, based on the estimation of time-varying propagating wavelets, we study the *Q* estimation from wavelets time-varying characteristics both in the time domain and frequency domain. The optimization method is used to scanning *Q* in order to minimize the difference between two wavelets at two different depths. The time-varying wavelet spectral match (TWSM) needs no spectral ratio or linear regression, therefore has better noise resistance than the logarithmic spectral ratio (LSR) method. The time-varying wavelet time-domain match (TWTM) has higher accuracy because of no spectral estimation. Tests on both synthetic and real data demonstrate that the two methods can achieve a fast *Q* estimation, and have better robust *Q* estimation on low SNR data than the time-varying wavelet logarithmic spectral ratio (TWLSR). The synthetic data examples also show relation between the *Q* estimation accuracy and the time interval of two wavelets, which means the *Q* estimation has resolution limitation.

Keywords: *Q* estimation, attenuation, time-varying wavelet, logarithmic spectral ratio, resolution.

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Volcanic rock morphology characterization on walkaway VSP data. Wang Chong[1], Cai Zhidong[1], Han Jianxin[1], Zhang Xiaolu[1] and Jin Yixin[1]. OGP, 2018, 53(1): 147-152.

It is always very difficult to interpret volcanic rocks on conventional seismic data. So we try to describe volcanic rocks on walkaway VSP data. We demonstrate in this paper an application example in Santanghu Basin, Tuha Oilfield. A walkaway VSP survey was conducted in the Well M68 area, the walkaway VSP data was properly processed, and high-resolution and high-fidelity walkaway VSP P-wave imaging was achieved. Based on this data, volcanic rocks are exactly characterized, and vertical lithologic interfaces of both volcanic rock reservoirs and source rock reservoirs are carefully identified. The horizontal shape and distribution of volcanic rocks are also identified. Our volcanic rock morphology characterization is proved by the latter well drilling.

Keywords: volcanic rock, walkaway VSP, high resolution, reflection wave imaging, characterization

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Prestack stochastic inversion based on the quantum annealing Metropolis-Hastings algorithm. Zhang Guangzhi[1,2], Zhao Chen[1], Tu Qicui[3], Liu Jiang[3], Zhang Jiajia[1,2] and Pei Zhonglin[1]. OGP, 2018, 53(1): 153-160.

The conventional MH (Metropolis-Hastings) algorithm is a common stochastic inversion method. It can get a lot of samples from the posterior distribution to obtain more reliable parameter estimation and uncertainty information of inversion results. But the MH algorithm cannot fully search on it for more complex parameter space. For this purpose we propose a prestack stochastic inversion based on the quantum annealing MH algorithm to improve the computational efficiency and stability of the inversion. Tests on synthetic and real data show that the proposed method has higher convergence efficiency than the conventional MH algorithm.

Keywords: seismic stochastic inversion, prestack seismic inversion, quantum annealing, Metropolis-Hastings (MH) algorithm

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Prediction of favorable oil-gas transportation parts of oil-source faults on seismic data. Fu Guang[1] and Wang Haoran[1]. OGP, 2018, 53(1): 161-168.

Prediction of favorable oil-gas transportation parts of oil-source faults is a key issue in the hydrocarbon exploration. Favorable oil-gas transpor-

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tation parts were affected by many factors such as fault activity characteristics and development characteristics. Based on favorable oil-gas transportation parts and their influence factors, we first determine fault-plane ridges and transfer zones on seismic data, and predict quantitatively activity rates at different parts of faults. Then we superpose fault-plane ridges, transfer zones, and fault activity rates together to predict favorable oil-gas transportation parts. The proposed approach is applied to 6 faults in the Langgu Area, Jizhong Depression, Bohai Bay Basin. The results indicate that Faults F^1 and F^2 have 4 favorable oil-gas transportation parts, which has good coincidence with the discoveries. Our practice proves feasibility and effectiveness of the proposed approach.

Keywords: seismic data, fault, favorable parts, oil-gas transportation, prediction

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Volcanic rock lithofacies identification step-by-step with multi-methods. Guo Juanjuan[1], Xu Xuelong[2], Huang Linjun[1], Wang Yanjun[1], He Xianying[2] and Wei Cairu[1]. OGP, 2018, 53(1): 169-177.

Volcanic rock lithology and lithofacies are very complex. Volcanic rock lithofacies identification with a single method usually leads to multiple solutions. Therefore we propose an approach to volcanic rock lithofacies identification with multi-methods. Based on multi-disciplines (cores, well logging, and seismic) data, we conduct the identification step-by-step with multi-methods such as rock-electricity crossplot, seismic facies recognition, horizon seismic attributes, isochronous stratigraphic model, and geological model. With the constraints of 3D geological model and sensitive-parameter lithologic model, this approach distinguishes eruption facies volcanic breccia, effusion facies andesite, and volcanic sedimentary facies tuff based on drilling, logging and seismic data. The following understandings are obtained on our volcanic lithofacies identification in the XQ Area, Junggar Basin: ① On GR-RT and AC-DEN crossplots, effusive facies lava, eruption facies volcanic breccias, and volcanic sedimentary facies can be properly identified, but eruption facies volcanic breccia and volcanic sedimentary facies cannot be identified; ② With optimal attribute analysis of drilling information and seismic data, volcanic breccia belongs to eruption facies, andesites, basalt, and dacite belong to effusive facies, and tuff, tuffaceous glutenite, tuffaceous sandstone, and tuffaceous shale belong to volcanic sedimentary facies.

Keywords: carboniferous system, volcanic lithofacies, rock-electricity relationship version, sensitive-parameter lithologic model, amplitude attribute, Junggar Basin

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Thin bed thickness estimation based on an improved phase objective function. Wang Peng[1], Hu Xiangyang[1] and Wei Shuijian[1]. OGP, 2018, 53(1): 178-185.

As one of the important seismic attributes, phase contains reflection structure information. Based on the assumption of the double-reflection coefficient combination and the seismic wavelet constant phase, we derive a new relationship between the phase spectrum and the stratum thickness. And we use this relationship to estimate thin bed thickness. Compared with conventional phase-to-thickness relationship, the new relationship avoids the singularity problem of phase tangent functions, reduces the instability caused by different frequency bands, and improve the feasibility of thin bed thickness estimation with phase spectrum. Real data applications show that thin bed thickness estimated by the proposed approach matches very well with that interpreted on logging data, which provides a good base for the latter exploration deployment.

Keywords: thin bed, phase spectrum, thickness, tangent, robustness

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Field tests of the Surface Electromagnetic Prospecting System. Li Meng[1,2] and Di Qingyun[1,2]. OGP, 2018, 53(1): 186-194.

The Surface Electromagnetic Prospecting (SEP) System developed by ourselves have already been tested in China and abroad. The test comparison with other similar field instruments was carried out. Test results show that the SEP System has similar specifications with the other instruments, and some performances are even better. In order to test the consistency, stability and reliability of the SEP System (including electric receiver stations and magnetic sensors), well-designed batch comparison tests have been conducted in Zhangbei, Hebei. In the tests the SEP System received natural source electromagnetic data and controlled source electromagnetic data. The apparent resistivity of the natural source field and the controlled source field are consistent, and the errors are within a reasonable tolerance. The comparison of a large amount of data proves both the receiver stations and the magnetic sensors have reliable and stable performances. Our practice proves the effectiveness of our comparison test approach, and the test results

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show that the SEP System can acquire high-quality electromagnetic data for the deep hydrocarbon and other mineral resource exploration.
Keywords: Surface Electromagnetic Prospecting System (SEP), comparison test, natural source field, controlled source field, consistency, stability, reliability
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Anti-noise quantitative analysis of the m-sequence in the multi-transient electromagnetic method and its coding parameter optimization. Yuan Zhe[1], Zhang Yiming[1] and Zheng Qijia[1]. OGP, 2018, 53(1): 195-205.

The multi-transient electromagnetic (MTEM) method can achieve good anti-noise performance with transmitted waveform coded by m-sequence. However, m-sequences with different coding parameters have different anti-noise performance. First, we reveal significant differences in the identification precision of different coding parameters. Then we build an identification system by constructing a model of the identification progress. For the identification system, the input is an impulse to the earth, and the output is the response of the impulse. The noise attenuation at a specific frequency can be quantitatively analyzed by the amplitude-frequency response of the identification system. Based on this method, effects of coding parameters on the anti-noise performance are summarized by numerical simulation and the coding parameter optimization is further discussed and concluded. Field experiments demonstrate the validity of the proposed method and coding parameter optimization conclusions.
Keywords: multi-transient electromagnetic (MTEM), m-sequence, coding parameter, anti-noise performance, optimization
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Magnetotelluric data de-noising based on wavelet transform and independent component analysis. Cao Xiaoling[1,2,3], Liu Kaiyuan[4] and Yan Liangjun[1,2]. OGP, 2018, 53(1): 206-213.

A de-noising method for magnetotelluric data with independent component analysis based on wavelet analysis is presented. Simulation experiments on synthetic signals show that the de-noising stability of the proposed method is better than the conventional wavelet-threshold de-noising method. Tests on real magnetotelluric data demonstrate that this method can effectively remove noise except at the extreme-low frequency band. So the proposed method provides a guarantee for the subsequent data processing quality.
Keywords: wavelet analysis, independent component analysis, magnetotelluric data de-noising
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Current status and development trends of seismic reservoir prediction viewed from the exploration industry. Gan Lideng[1], Zhang Xin[1], Wang Yaojun[2], Kong Liyun[1] and Yang Tingqiang[1]. OGP, 2018, 53(1): 214-225.

In this paper, we review new requirements of structure, lithology, stratigraphy, and unconventional reservoir exploration for seismic technology, and discuss seismic reservoir prediction. According to the seismic wave definition, the prediction hypotheses, and real media characteristics, we summarize available techniques of reservoir prediction, and analyze development trends in the future. For the future research of seismic reservoir prediction, we offer the following suggestions: A. Based on continuous, heterogeneous, anisotropic media and elastic wave propagation theories, focusing on rock physics analysis and amplitude-preserved processing; B. Based on attenuation and dispersion, developing prediction approaches with azimuthal attributes; C. Developing prediction tools for lithologic and unconventional reservoirs with multi-disciplines' data; D. Ensuring the prediction quality and accuracy. So a complete series of seismic reservoir prediction approaches for complex lithology, stratigraphy, and unconventional hydrocarbon exploration will be established.
Keywords: reservoir predication, exploration field, medium, rock physics, amplitude-preserved processing, pore geometry and structure, dispersion and attenuation
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