ABSTRACTS

Applications of converted-wave anisotropic prestack time migration in LMD area. Zhang Liyan[1], Li Ang[1], Pei Jiangyun[1] and Song Zongping[2]. *OGP*, 2012, 47(5): 683～689

Media anisotropy affects greatly converted-wave imaging for large offset gather. Based on non-hyperbolic NMO equations of converted-wave anisotropy, we propose a simple and practical high precision Gamma (Average velocity ratio of P and S wave) field building method and a structure velocity scanning method in this paper. These two methods can obtain accurate Gamma field and converted-wave RMS velocity field. Migration travel time can be calculated by anisotropy double square root scattering travel time equation. The application of the methods on 3D3C data in LMD area, Daqing Changyuan shows good results with clearer breakpoint and section, and more continuous events.

Key words: converted wave, anisotropic, prestack time migration, converted wave RMS velocity field, scatter wave travel time

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Seismic wavefield separation and denoising for P-P wave and P-S wave by singular value decomposition (SVD). Shen Hongyan[1,2] and Li Qingchun[3]. *OGP*, 2012, 47(5): 690～697

As one of seismic data processing approaches, singular value decomposition (SVD) filter uses the lateral coherence difference of seismic signals to achieve wavefield separation and denoising. However, the propagation characteristics, apparent velocities and coherences are quite different between P-P wave and P-S wave. In this paper, a new idea of SVD application is proposed. Based on apparent velocities information, we first apply normal moveout (NMO) processing respectively on P-P wave and P-S wave to align P-P wave and P-S wave into the best horizontal coherence. Then we extract reconstructed signals of singular values from target signals by SVD separately on P-P wave and P-S wave, Finally P-P wave and P-S wave separations as well as noise attenuation are obtained.

Key words: singular value decomposition (SVD), P-P wave, P-S wave, wavefield separation, denoising, normal moveout (NMO)

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An improved method for P-P and P-SV wave time matching. Gong Xueping[1,2], Chen Shuangquan[1,2] and Li Xiangyang[1,2]. *OGP*, 2012, 47(5): 698～704

As the velocity ratio is changing with time, the time matching from P-SV to PP time domain will distort seismic wavelet which includes waveform stretch and phase delay. To solve this problem, we propose an improved method for P-P and P-SV wave time matching. This method, based on Fourier's time stretch theory, can correct simultaneously wavelet amplitude and phase resulted from the different stretch value with the seismic travel time. The modeling data results of a well log data indicate that the method can correct simultaneously wavelet amplitude and phase. And the method is still stable when the data is noised.

Key words: velocity ratio, converted wave, waveform matching, spectrum, filter

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Three dimensional cone filtering. Wang Jinlong[1,2] and Hu Zhiquan[1,2]. *OGP*, 2012, 47(5):705～711

Making full use of the apparent velocity difference between seismic reflection signal and linear interference in three dimensions, the three dimensional cone filtering could obtain an effective suppression of surface waves. This filtering approach first transforms seismic data from time-space domain to frequency-wavenumber domain with three dimensional Fourier transform, and then designs a cone filter to suppress surface waves with low apparent velocity in order to preserve signals. Compared to the conventional two dimensional apparent velocities filtering, the three dimensional cone filtering uses the space distribution of seismic signal and chooses reasonable velocity values. So it could fully remove surface waves and preserve seismic signals. Moreover, for hyperbolic surface waves of far offsets in three dimension geometry, this cone filtering can also obtain good result for remove of surface waves, but the conventional two dimensional apparent velocity filtering cannot.

Key words: three dimensional cone filtering, cross spread, surface wave, denoising, frequency-wavenumber domain

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Prestack reverse time migration on GPU/CPU co-parallel computation. Liu Wenqing[1,2], Wang Yuchao[2], Yong Xueshan[2], Wang Xiao[2], Shao Xichun[2], Gao Houqiang[2] and Liu Qiuliang[2]. *OGP*, 2012, 47(5): 712～716

Based on the GPU/CPU co-parallel system, we achieve reverse-time extrapolation of the wavefield for the largest amount of computation through the GPU, improve wavefield extrapolation method parallelism using the idea of random velocity boundary, and solve the I/O problems of large-scale storage. Through optimizing the Laplace operator, the low-frequency noise from cross-correlation imaging condition is removed. Numerical experiments show that GPU/CPU co-parallel system has very high computational efficiency. In practical applications, we obtain not only high computational efficiency but also good imaging results. The theoretical model and real salt dome data processing resufts show the correctness of the algorithm.

Key words: reverse time migration, wave equation, imaging condition, GPU/CPU co-operating parallel computation, random velocity boundary

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A shear velocity estimation method for carbonate rocks based on the improved Xu-White model. Zhang Guangzhi[1], Li Chengcheng[2], Yin Xingyao[1] and Zhang Jinqiang[3]. *OGP*, 2012, 47(5):717～722

In a number of actual geophysical data, the shortage of shear velocity will bring some difficulties for prestack seismic attributes analysis and prestack seismic inversion. However, shear velocity estimation methods of clastic rocks have been developed more mature than shear velocity estimation methods of carbonate rocks. In this work, based on classic Xu-White model, the improved Xu-White model for carbonate rocks is constructed from rock physics theory. Then through an analogy study of empirical equations for carbonate rocks built by Pickett, Castagna and so on, the empirical relations for the practical carbonate zones. Finally the empirical equations and the improved Xu-White model are used to calculate shear velocity for the practical carbonate zone. The estimated results illustrate that higher predicted accuracy of shear velocity can be obtained by the improved Xu-White model.

Key words: shear velocity estimation, carbonate rocks, improved Xu-White model, empirical equations, rock physics, well data

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A method for S-wave velocity estimation based on equivalent elastic modulus inversion. Xiong Xiaojun[1], Lin Kai[1] and He Zhenhua[1]. *OGP*, 2012, 47(5): 723～727

To deal with the difficulty of calculation of matrix mineral elastic modulus in regular S-wave velocity estimation methods based on Xu-White model, the paper proposes a novel method for S-wave velocity estimation based on equivalent elastic modulus inversion. Firstly, the method calculates the range and initial value of Poisson's ratio of dry core sample and equivalent bulk modulus of matrix mineral. Then, it calculates the fluid section by two different methods based on inversion method, and obtains the Poisson's ratio of dry core sample and equivalent elastic modulus of matrix mineral. Finally, this method uses the approximative Xu-White model to estimate the S-wave velocity. Through study of the equivalent elastic modulus of matrix mineral, the method effectively improves the accuracy and reliability of S-wave velocity estimation by reducing the number of target parameters.

Key words: equivalent elastic modulus, inversion, fluid section, S-wave velocity estimation

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P-wave attenuation by fracture parameter on physical models. Yin Zhiheng[1,2], Di Bangrang[1], Wei Jianxin[1], Zhang Zheng[1], Zhang Sihai[1] and Wu Mansheng[1]. *OGP*, 2012, 47(5): 728～734, 753

Three sets of physical models are built based on Hudson theory with different fracture density, aperture and length. Test amplitudes of P-wave on the models are recorded by the pulse transmission method. Experimental data are compared with theoretical data from Hudson theory and quality factor Q of models are obtained using classic spectral ratio method for determining attenuation. The study results show: ① With the increase of fracture density, amplitude has a little decrease and azimuthal amplitude anisotropy. By the analysis of comparing results, it can be seen that Hudson theory's prediction is exact. ② With the increase of fracture length, amplitude increases in the mass and the situation is similar in X and Z directions. But the prediction of Hudson theory is different with small decrease. ③ With the increase of fracture opevture, the variation of amplitude is much bigger than the prediction, which means that the theory underestimate the effect of fracture length. ④ The anisotropy of velocity and amplitude changes similarly with different fracture parameters. The influence of fracture aperture is most obvious and attenuation anisotropy is more sensitive to the change of fracture parameter than velocity anisotropy.

Key words: fracture density, fracture aperture, fracture length, physical modes, velocity anisotropy, attenuation anisotropy

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Estimation of stratigraphic absorption parameter based on center frequency method. Wei Wen[1], Li Hongmei[1], Mu Yuqing[2], Wang Shugang[1] and Wang Hong[1]. *OGP*, 2012, 47(5): 735～739

Aiming for gas-bearing formation identification, this paper presents a method for estimating stratigraphyic absorption parameter (Q value) by seismic signal central frequency. Firstly an energy distribution function can be obtained by a time-frequency transform on seismic signals with the S-transform. Then based on this function, the central frequency and the relation between the central frequency and the stratum Q value are calculated, and the equivalent strata Q value is obtained. And then the single formation Q value is work out. In

the forward model, the central frequency of the gas-bearing formation becomes smaller than non-gas-bearing formations, and strong absorption are presented in the *Q* value profile. The phenomena make sure of the feasibility of the method in strata *Q* value estimation. The *Q*-value estimation by this method in Yong'an, Dongying Sag reveals the actuality of the absorption characteristics.

Key words: *Q*-factor, absorption attenuation, S-transformation, center frequency, gas reservoir detection

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Seismic attribute reduction based on covering rough set and its applications. Liu Hongjie[1], Lou Bing[1], Liu Taoping[2] and Wei Jianjie[3]. *OGP*, 2012, 47(5): 740～746

In oil & gas prediction, it is not always true that the more the index variables of seismic attribute data are, the better effect of prediction is. On the contrary, the classification accuracy will reduce by the redundant index variables because of the calculation error. Nowadays, rough set is mostly applied to optimize seismic attributes in the seismic attribute reduction. However, it is difficult to achieve the equivalence relation in some cases, and the process of discretizing continuous attributes can lead to the distortion of the original data. Therefore, the seismic attribute reduction based on the covering rough set is presented in this paper. This approach not only solves problems mentioned above, but also overcomes limits in rough set application, and makes the rough set theory more generalized. The simulation and actual experiments reveal that the results of the seismic attribute reduction application can improve oil & gas prediction precision.

Key words: rough set, covering rough set, seismic attribute, attribute deduction, oil & gas prediction

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The seismic multi-attribute clustering method based on quantum Monte Carlo method. Wei Chao[1], Zheng Xiaodong[1], Li Jinsong[1] and Li Meng[1]. *OGP*, 2012, 47(5): 747～753

Multi-attributes clustering is an important way for drawing underground geologic features from a large number of seismic attributes. For improving the effectiveness of the attributes clustering, this paper introduces quantum Monte Carlo method with stronger optimization ability into the clustering to adjust the inherent category number of data dynamically according to the characteristics of the data structure. By increasing the correlation analysis in the process of clustering for estimating each attribute weight, seismic attributes which are sensitive to geological features can be highlighted. The proposed variable scale method can show details together with macro common attribute characteristics to reduce the influence of attribute cross information. Examples show that the method proposed in this paper could be very good at mining the inherent characteristics of data to improve reservoir prediction accuracy.

Key words: attribute clustering, quantum Monte Carlo method, weight, variable scale clustering

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Gas reservoir detection based on local frequency attributes. Chen Shuangquan[1,2] and Li Xiangyang[1,2]. *OGP*, 2012, 47(5): 754～757

As time function of seismic wave propagation in subsurface, seismic trace is the response characteristic of reflection signal from the layers. Com-

plex seismic trace analysis method is based on the Hilbert transform of the seismic signal, from which instantaneous amplitude, instantaneous phase and instantaneous frequency can be calculated. Three instantaneous attribute parameters play an important role in reservoir prediction and characterization. However, the frequency-dependent characteristic induced by the existed hydrocarbon in reservoir porous medium couldn't be found in the instantaneous frequency attribute section. The main reason is the lower resolution and complicate interpretation resulted from the phase shift effect on the computing process. In this paper, the conventional instantaneous frequency calculation method is reviewed and a novel local attribute technique is introduced into the local frequency attribute calculating method. The application of real field seismic datasets for hydrocarbon detecting in gas reservoir area indicates that the local frequency attribute can show the frequency-dependent response with the fluid in reservoir with higher signal-to-noise ratio and interpretation ability. Moreover, the integrated interpretation combined with the converted-wave seismic attribute can improve the ability of reservoir prediction and qualitative fluid detecting.

Key words: hydrocarbon detecting, local attribute, reservoir characterize, instantaneous frequency, complex seismic trace

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Seismic curvature calculation based on Huber norm. Li Xin[1,2], Wang Zhenli[1,2], Chen Yuhong[2,3] and Duan Qiuliang[1]. *OGP*, 2012, 47(5): 758～765

There are some drawbacks in curvature calculation based on L2 norm. Using 2D median filtering or distance-weighted median filtering, this conventional method leads fitting surface deformation and large curvature errors for data with anomalies. To solve this problem, seismic curvature calculation based on Huber norm is proposed in this paper, which treats large residuals with L1 norm and small residuals by L2 norm. Model tests suggest that the method can describe more fine properties about abnormal values and jump values than the least squares method. Field data tests indicate that finer and more accurate seismic curvature results can be obtained by the method.

Key words: Huber norm, horizontal curvature, least squares method

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Hydrocarbon recognition based on spectrum absorption characteristics of reservoir. Diao Rui[1] and Feng Yuping[2]. *OGP*, 2012, 47(5): 766～772

Improved generalized S transform of window function normalized energy improves the frequency resolution with time resolution not lowering at the same time. Through the forward modeling of visco-elastic wave equation, we discuss in this paper spectrum absorption characteristics of reservoir based on improved generalized S transform. When seismic waves pass through reservoir, high frequency energy attenuation is more severe than low frequency. So spectrum absorption characteristics show that low frequency energy is relatively augmented, and high frequency energy relatively diminished. The spectrum absorption characteristics can indicate the concentrated degree of petroleum in reservoir. The frequency spectrum analysis of model data and real seismic data near wells proves the effectiveness and feasibility of this method.

Key words: spectrum absorption characteristics, reservoir characterization, hydrocarbon recognition, generalized S transform, viscoacoustic medium, wave equation forward modeling

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High precision seismic time-frequency spectrum decomposition method and its application. Huang Handong[1,2], Guo Fei[1], Wang Jiabei[1] and Ren Dunzhan[3]. *OGP*, 2012, 47(5):773～780

Because of Heisenberg's uncertainty principle, the linear algorithms of time-frequency spectral decomposition, for example wavelet transform and generalized S transform, cannot simultaneously have high resolution in time and frequency domains. Overcoming the window function limit, the matching pursuit can precisely characterize signal features in time and frequency domains. This paper firstly discusses the algorithm theory of matching pursuit to seismic signal, and then put forward the reasonable improvement to standard Morlet wavelet, which can perfect the time-frequency atomic database, thus enhancing the precision of seismic signal matching decomposition. Based on the time-bandwidth of Morlet wavelet, the paper finally uses window treatment technology to dynamically scan matching wavelet atoms at the same time in multi-windows, so that calculation efficiency can be appropriately increasing. The model test and actual data analysis show that matching pursuit of seismic signal based on improved Morlet wavelet is more precise and efficient, and has some antinoise ability, suitable for quantitative analysis of the spectrum variation of seismic data, which will be helpful to study oil & gas reservoir distribution.

Key words: seismic time-frequency spectrum decomposition, matching pursuit algorithm, Morlet wavelet, calculation efficiency, time-frequency property

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Application of reservoir dynamics data in seismic identification and evaluation of minor faults. Wang Xuejun[1], Wei Xiaodong[1], Wang Zhaofeng[1], Yu Zilang[2] and Pan Xiaolu[1]. *OGP*, 2012, 47(5):781～785

Identifications and evaluations of minor faults or their lateral sealing property are the most difficult challenges in seismic interpretation. The identifying and evaluating the lateral sealing of minor faults are important basis for adjustment program in oilfield development middle and later phases. In this paper, reservoir dynamics data have been intergraded with seismic data for this purpose. Therefore, their advantages are adapted widely and their disadvantages are avoided as far as possible. Well dynamics data are used for making up seismic vertical resolution, and seismic data is used for making up shortage of characterizing fault spatial features. The application demonstrates that the integration of seismic data and reservoir dynamics can not only improve the ability of minor fault identification, but also evaluate the minor fault's lateral sealing properties. We believe this process will contribute to the understanding of reservoir geology and provide a reference for oilfield adjustment plans.

Key words: reservoir dynamics data, minor fault, seismic identification and evaluation

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Hydrocarbon pooling characteristics and pooling patterns in the south fault belt, West Pearl River Mouth Basin. Zhang Yingzhao[1,2]. *OGP*, 2012, 47(5): 786～794

Based on the comparison of play source rock and hydrocarbon phase, hydrocarbon pooling characteristic and difference in the south fault belt from west to east have been summarized, and tectonic movement difference was thought to be the main controlling factor causing difference of hydrocarbon pooling characteristic in south fault belt, West Pearl River Mouth Basin. Three kinds of multi-

hydrocarbon pooling patterns have been put forward by the differences of structural style and valid source-hydrocarbon: the first pooling pattern is "two periods of tectonic inversion—Wenchang source rock-derived" developed in the west segment of the south fault belt. Hydrocarbon generating, pooling and distribution are controlled by early Oligocene Enping period and mid-Miocene Hanjiang period tectonic inversion movements. Hydrocarbon derived from Eocene Wenchang Formation was characterized by multi-pooling. The second pooling pattern "late tectonic inversion—Enping source rock" existed in the middle segment of the south fault belt, hydrocarbon generating, pooling and distribution are controlled by lateral extension difference, tectonic subsidence difference and Mid-Miocene Hanjiang period tectonic inversion movement, hydrocarbon derived only from Lower Oligocene Enping Formation, characterized by multi-period pooling and vertically well-superpositioned pooling. The pooling third pattern is the "continuous extension—Wenchang and Enping dual source rock" existed in the east segment of south fault. Hydrocarbon generating, pooling and distribution are controlled by growth fault movement and tectonic subsidence shift towards east, and hydrocarbon derived from both Wenchang Formation and Enping Formation, characterized by multi-source and multi-period pooling.

Key words: West Pearl River Mouth Basin, south fault belt, hydrocarbon pooling characteristics, difference of tectonic movement, hydrocarbon pooling pattern

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Sedimentary sequences in Haian Depression and control on reservoir of the Paleocene. Ran Huaijiang[1], Si Baoling[2], Cheng Fanghong[2] and Fan Leyuan[1]. *OGP*, 2012, 47(5):795～802

Using data from cores, well logging, seismic and core enperiment, the sequence stratigraphy analysis and sedimentary facies identification of the Paleocene of Haian Depression in Subei Basin are conducted. The distribution and allocation relations of the sedimentary sequence system are obtained, revealing the distribution regularity of the major reservoirs in this area. The work shows that the Haian Depression had undergone four tectonic uplift movements (Yizheng movement, Wubao movement, Zhenwu movement and Sanduo movement) during the basin fault-depression stage from Taizhou Formation to Sanduo Formation periods, and 3 secondary-order sequences were formed. In those secondary-order sequence stratigraphic frameworks, the Paleocene of Haian Depression can be divided into 7 third-order sequences and 17 system tracts, and the main oil bearing system tracts include the lowstand system tract of SQ1-1, SQ1-2 and SQ3-1, the highstand system tract of SQ1-3, and the lake transgressive system tract of SQ2-1. There are 4 kinds of sedimentary systems identified in the main oil bearing system tract, including fan delta, river delta, braided delta and lake facies. The differences of sedimentary characteristics and the space location relationship of the system tracts cause the different matching relationship of favorable source-reservoir-cap assemblages, including the source-reservoir-cap assemblages of the lowstand system tract of SQ1-1, SQ1-2 and SQ3-1, the source-reservoir-cap assemblages of the highstand system tract of SQ1-3, and source-reservoir-cap assemblages of the lake transgressive system tract of SQ2-1.

Key words: Haian Depression, Paleocene, sequence stratigraphy, sedimentary facies, system tract, source-reservoir-cap assemblage

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Pseudo-acoustic log construction based on information fusion from probabilistic neural networks. Liu lihong[1], Peng Zhenming[1], Huang Dongshan[2], Li Quanzhong[1] and Tao Tao[1]. *OGP*, 2012, 47(5):803～807

An approach to pseudo-acoustic log curve con-

struction based on probabilistic neural networks (PNN) is presented in the paper. Firstly, the basic mathematical model of PNN is discussed. Then, a multi-input and single-output PNN network topology which is fit multi-source logging information fusion is designed on the basis of the model. After that, the output of the new model with the minimum fit error criterion is derived using PNN interpolation function. Finally, the actual logging data is processed by the model, and a fast pseudo-acoustic curve construction is adaptively obtained. The processing results show the rationality and effectiveness of the method.

Key words: probabilistic neural network, model design, logging information fusion, pseudo-acoustic log construction

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Joint inversion of gravity, magnetic and seismic data of the South Yellow Sea Basin. Hou Fanghui[1,2], Tian Zhenxing[2], Zhang Xunhua[2], Zhang Zhixun[2] and Li Sanzhong[1]. *OGP*, 2012, 47(5):808～814

The south Yellow Sea Basin, based on the pre-Nanhua metamorphic basement of the Lower Yangtze Platform, is a polycycle basin with a sandwich-type construction. The geologic evolution of the basin can be divided into three stages: the Nanhua-early and middle Triassic marine basin stage, the late Cretaceous-Paleogene graben fault basin stage and the Neogene-Quaternary depression basin stage. Gravity and magnetic anomalies restrained by seismic data are inverted by 2.5D gravity-magnetic-seismic inversion from newly acquired seismic, gravity, and magnetic data. The inversion results indicate that the joint inversion method is helpful to research the contact relation between the basin and mountains, and to identify fault distribution, deep targets and favorable structural traps in future oil and gas exploration.

Key words: joint inversion, seismic profile, tectonic interpretation, South Yellow Sea Basin

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Boundary detection and interpretation by magnetic gradient tensor data. Ma Guoqing[1], Li Lili[1] and Du Xiaojuan[1]. *OGP*, 2012, 47(5):815～821

In this paper, we propose a method for boundary detection and interpretation of magnetic gradient tensor (MGT) data by directional analytic signal. The advantage of this method is that it does not need some prior information about the source shape in the inversion, and the inversion results are less affected by the magnetization direction. The definition of the directional analytic signal and the expression for the boundary detection of the source are given in the paper, and the combination of the directional analytic signal and Euler deconvolution are used to interpret the MGT data. This new method is tested on synthetic magnetic anomalies generated by different models, and the inversion results show that the method can successfully identify the source boundary and interpret the MGT data. The method is also applied to real measured magnetic data, and the distribution of subsurface magnetic sources is obtained.

Key words: analytic signal, tensor, boundary, Euler deconvolution, magnetic anomaly

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