

ABSTRACTS

Pitfall of cross-hole seismic exploration and way out. Li Qing-zhong and Wang Jian-hua. *OGP*, 2004, 39(1): 1~11

The object of cross-hole seismic exploration is to obtain the underground seismic data having both higher frequency and high resolution. But recent cross-hole seismic exploration has fallen a pitfall, that is, most of the rays in cross-hole seismic exploration is in the region beyond critical angle. Through some cases analysis, the paper determined whether the incident angle of ray in cross-hole seismic exploration being less than critical angle or larger than critical angle is the mark of success or failure. Adopting forward modeling of elastic wave-equation in the paper, when beds are horizontal and shooting is in the borehole, the seismic wavefield quickly surpasses the critical angle on both left and right sides, formed very complex wavefield confusion zone (the authors call it as "the tip of a horn"). The ray theory is no longer available in this zone. The first break cannot be correctly acquired, resulted in very difficult of cross-hole imaging. Therefore, the paper clearly pointed out that the way out for the next developing cross-hole seismic exploration lies in controlling the incident angle of ray within critical angle and ensuring the source to have sufficient energy.

Key words: cross-hole seismology, incident angle, critical angle, Zoeppritz's equation, elastic wave-equation

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Study on correction of well deflection by tomography of cross-hole first arrival data and application. Kong Qing-feng, Zuo Jian-jun, Chen Shi-jun and He Xing-hua, Zhang Jian-zhong. *OGP*, 2004, 39(1): 12~16

Because of dipping bed during drilling process, the wellhead-crossed trace of well is no longer vertical line, but is the spatial curve, which resulted in deviation of first break time used by cross-hole tomographic calculation, affecting the imaging precision. For that reason, the paper presented a method for correction of well deflection. The tests of synthetic cross-hole seismic data and real data showed that the method can solve the errors of first break time caused by well deflection, improv-

ing the precision of velocity inversion.

Key words: cross-hole seismology, well deflection, tomography, direct arrival, travel time

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Practical methods for 2-D wave equation prestack depth migration. Fang Wu-bao, Sun Jian-guo and Chen Jiu-bing. *OGP*, 2004, 39(1): 17~23

Practical methods for 2-D wave equation prestack depth migration are being further developed and completed. The paper only compared four representative methods, that is Split-Step Fourier (SSF), Fourier Finite-Difference (FFD), Generalized Screen Propagators (GSP) and Finite-Difference in Space-Frequency Domain (XWFD). All these methods have the following thinking: the velocity field is split into background field and disturbed field, the wavefield continuation of background field is completed by phase-shift method and migrated imaging of disturbed field is fulfilled by different methods, so each method has his own characters. The paper tested and analyzed the pulse responses corresponding to four methods and migrated imaging processing was carried out by using Marmousi model and real seismic data separately at the same time, the calculated results are more ideal. The comparison of the results in these wave equation migration methods with those by Kirchhoff method is also carried out. The analyses showed the former is superior to the latter in resolution and imaging capacity for weak signal.

Key words: two dimension, wave equation, prestack depth migration, pulse response, data test, correlation analysis

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Filtering characters of seismic reflection wavefield on coarse interface. Sun Cheng-yu. *OGP*, 2004, 39(1): 24~28

Using Kirchhoff integration, the paper deduced the expression of seismic reflection wavefield on coarse interface, studied theoretically the filtering characters of seismic reflection on coarse interface and proved the theoretically-induced results by numerical cases. The study showed that there exists a critical frequency f_c on a condition that the difference between undulate wavelength of coarse

interface λ_c and seismic wavelength λ is very small, the seismic wave components that their wavelengths are less than $2\lambda_c$ (or the frequency components are great than the critical frequency f_c) will be strongly distorted after reflection on coarse interface, that is, having strong filtering action on high-frequency signal; but the filtering action can be neglected for the seismic wave components that their wavelengths are great than $2\lambda_c$ (or the frequency components are less than the critical frequency f_c). This critical frequency is also related to depth, the deeper the depth is, the higher the frequency is and the weaker the filtering action of coarse interface on reflection wave is.

Key words: coarse interface, seismic reflection, Kirchhoff integration, filtering

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Method for digitalization of seismic paper profile and application. Chen Shi-jun, Yan Shi-lei and Shi Yu-ping. OGP, 2004, 39(1): 29~32, 49

At present, the oilfields at home preserved a plenty of seismic paper profile and tape and did not build poststack seismic database, so that can not fully play the role of former legacy data. Using image processing technique, the paper got grating image after scanning the seismic paper profile, that has been transformed into vector data after digital processing, such as binary number representation, geometric correction, removing time axis and seismic waveform searching and detecting, and then these data were transformed into standard SEG-Y format, the further processing and interpretation can be carried out according to present seismic data processing techniques. It can be seen from digital processing of former seismic paper profile that the resulted digital seismic data can restore original face of old seismic paper profile, having ideal effects and providing a feasible way for further processing and interpretation of seismic data that have not been built up the poststack seismic database. Because the legacy data have not been carried out the amplitude hi-fi processing, so post-digital processed seismic data only can be suitable for geologic structural interpretation.

Key words: seismic profile, scanning, image processing, digitalization

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Detection of coherent data volume by wavelet mul-

ti-resolution and application. Zhang Jun-hua, Wang Yue-ying, Zhao Yong and Huang Guo-ping. OGP, 2004, 39(1): 33~36

Coherent data volume is a new seismic attribute detected from seismic data volume, which can more finely reveal such geologic phenomenon as fault, fracture, edge of rock body and unconformity as compared with original amplitude data volume. The key point of the paper is to discuss the method of third generation of coherent data volume based on calculating eigenwert. In order to attain the goal of using multi-scale frequency-divided data for interpretation, the paper applied the wavelet multi-resolution analysis to detect the coherent data volume. The applied results showed that the method improved the resolution of coherent data volume and enhanced the anti-noise ability, being favorable for fine interpretation of the anomalous bodies such as fault and fracture.

Key words: third generation of coherent data volume, wavelet transform, fault, multi-resolution analysis

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Tried processing of 3-D, 3-C seismic data. Xing Chun-ying, Wang Yun and Li Mao-rong. OGP, 2004, 39(1): 37~40

The geologic conditions of surface and underground of 3-D, 3-C seismic prospecting working area in Qianjiaying coal miner are complex and interference wave is serious, increasing the difficulty for data processing. The processing expounded by the paper used the self-made modules, including CCP gathers sorting, velocity analysis and NMO of converted wave (C-wave) and static corrections of converted wave. During the total C-wave data processing, we pay more attention to hi-fi processing of amplitude, the noise-removed tools that can destroyed the amplitude feature are not applied; the non-symmetric ray path is considered in static correction at receiver points; the density of velocity spectrum adopted by NMO is $1000\text{ m} \times 1000\text{ m}$, the spatial velocity field is smoothed; the full wave equation is used for migration and optimum coupled velocity of P-wave and converted S-wave migrated velocity is used for migrated velocity. The processing results showed the quality of sections can meet the demand of exploration.

Key words: seismic data processing, 3-D, 3-C, converted wave, sorting, linear interference, multiple, ratio of S/N

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Fracture detection by using full 3-D P-wave data. Zhang Gong-she, Ma Guo-guang, Song Yu-long and Zhu Shi-jun. *OGP*, 2004, 39(1): 41~44

Detection of fractured oil/gas reservoir is difficult problem generally recognized by current petroleum industry. According to self-similarity of fractured system and using full 3-D P-wave data, the data presented a new method for detection of fracture orientation and density by using multi-azimuth 2-D fractal technique. Its processing flow is as follows: ① enlarging bin processing, forming super CMP gather having 512 fold; ② forming 9 azimuth gathers; ③ NMO correction is carried out separately; ④ labeling amplitude and AVO stack according to azimuth; ⑤ detection and analysis of attributes according to azimuth. The applied results of the method to real data showed the method has advantages of good stability and high resolution when used for detection of fracture, having good applied prospect in the domain of oil/gas exploration and development.

Key words: reservoir prediction, full 3-D P-wave data, fracture detection, fractured azimuth, fractured density

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High-order statistic analysis of seismic dispersed wavefield. Zhang Li-qin, Zhan Qi, Zhu Pei-min and Wang Jia-ying. *OGP*, 2004, 39(1): 45~49

The ordinary processing method based on second order cumulant theory of random signal can't meet the demands of processing when the seismic signal is non-stationary, time-variation and non-minimum phase. The paper studied the method using high-order statistic to detect and identify non-uniform reservoir. The key of the method is to analyze the feature of high-order statistic of seismic signal based on high-order statistic. It is shown by theoretical analysis and detection of real seismic signal that the non-symmetry of generalized Gauss distribution of seismic sequence and the time-frequency double-spectrum analysis method can be used for detection of low-frequency signal when the seismic signal with generalized Gauss distribution is mixed with non-Gaussian or non-linear low-frequency signal. The method opened a new way for identifying the non-uniform carbonate reservoir.

Key words: seismic data processing, high-order statistics, seismic dispersed wavefield, high-order

cumulant spectrum, non-uniform reservoir

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High-precision 3-D seismic interpretation technique in Daqingze well area and applied effects. Liu Jun, Hou Ping, Wei Mao-lin, Qin Wen-ming and Lu Jun. *OGP*, 2004, 39(1): 50~55

In view of special geologic conditions such as the characteristic complex structures (small structure, small faulted block, small faulted nose and multi-faults) and complex reservoirs that have the thin, narrow and variant feature, we carried out the study of high-precision 3-D seismic interpretation. Using 3-D visualization, coherent data volume, horizontal slice and map analysis to finely interpret the 3-D structures, the ability using seismic exploration for identifying underground complex geologic structure and anomalous seismic reflecting body has been greatly improved. We used fine geologic prediction, attributes analysis and multi-well-constrained inversion technique for integrative lithologic interpretation of reservoirs having thin and interbedded characteristics, quantitatively predicted and described the rule of spatial distribution and variation for single sand bed. The set of techniques fully displayed the priority of 3-D exploration and achieved good seismic and geologic effects in oil-field exploration and development.

Key words: high-precision 3-D seismic exploration, coherent data volume, map analysis, seismic microfacies, logging-constrained seismic inversion, 3-D visualization, interpretation of 3-D data volume

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Time difference of time-lapse in layered medium. Li Lai-ling, He Yu-qian, Chen Ying, Mu Yong-guang and Chen Xiao-hong. *OGP*, 2004, 39(1): 56~59, 86

It's difficult to directly use poststack seismic data for studying time difference of time-lapse because the poststack seismic data corresponds to zero-offset data and the time difference of time-lapse is very small. The authors presented adopting prestack seismic data on far-offset to calculate the time difference of time-lapse. The order of time difference by finely calculation for multi-layered theoretical model can be reached to 10 ms and above. But for a layered medium, it's difficult to compute the vertical time difference directly by using prestack data on far-offset because the travelling paths of seismic wave before and after the reservoir

variation are very complex and shot-points and receiver-points are changed. Taking a double-layered medium as an example, the paper deduced and studied the time difference of layered medium, considered that using time difference of time-lapse produced by large incident angle can accurately calculate the velocity difference produced by replaced reservoir fluid, which attained the goal by using 4-D seismology to monitor the reservoir.

Key words: time-lapse seismology, seismic time difference, layered medium, prestack

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Making C-wave synthetic seismogram and correlation of P- and S-waves events. Ma Jing-feng, Fu Dan-dan, Liu Yi-feng, Wang Gui-shui and Gao Le. OGP, 2004, 39(1): 60~67

Making C-wave synthetic seismogram and correlation calibration of horizons together with P-wave data are the basis using multi-components seismic data for interpretation. When using full wave train logging data to make C-wave synthetic seismogram, it needs to consider the influence of many kinds of factors such as dip and anisotropy of bed as well as environment correction of S-wave logging data etc. In correlation of P-wave with P-SV wave data, it also needs to consider the influence of polarity, depth-time conversion of drilling data and bandwidth of wavelet etc. Starting from model data and real multi-components data of Yingge-sea basin, the paper studied the method and concrete step of C-wave synthetic seismogram as well as existed problems and solving method in co-operating P-with P-SV-wave for correlation calibration. The correlation calibration of real data showed the correctness of the method.

Key words: converted wave, synthetic seismogram, depth-time conversion, correlation of P- with P-SV-wave

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Study of logging and seismic information labeling. Ling Yun. OGP, 2004, 39(1): 68~74

During the process of lithologic oil-gas exploration, using logging data to label the seismic interpreting horizons is a most basic job. But traditional labeling methods mainly have following problems: ①there many solutions by using logging data to label surface seismic data, especially the problem of labeling time is more conspicuous; ②even the horizons nearby the well can be correctly labeled, but

for the rapidly-changed lithologic reservoir in space, the top and bottom of the reservoir can not be correctly detected, which cannot effectively extrapolate the logging information, resulted in unable to detect the seismic attributes along the horizons and effectively interpret the lithologic body. In view of above-existed problems and combining with the feature of lithologic oil-gas reservoir, the paper presented a new mode using logging data to label the seismic data, which is the label based on "referential marker bed" and based on the thought that the detection and interpretation of attributes is to use referential marker bed. Defined the "referential marker bed", the paper gave a set of concrete methods for detecting the seismic attributes based on referential marker bed. Through using real logging data for labeling seismic data and detection and interpretation of seismic attributes based on referential marker bed, the method finally gained an ideal lithologic interpreted results.

Key words: acoustic logging, VSP, surface seismic exploration, referential marker bed, target

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Random seismic inversion and its application in Chengbei No. 35 well-zone. Sheng Guo-qiang, Meng Xian-jun, Wang Yu-mei, Niu Xue-min and Sun Zhen-tao. OGP, 2004, 39(1): 75~81

Random seismic inversion is an important technique that can be used for oilfield development and to improve the precision of reservoir description and oil-gas identification. Closely combining the geostatistical modeling with seismic inversion to complete the random seismic inversion can result in distributing characters of petrophysical parameters that the variety of underground objective reservoirs has, which the resolution has the advantage of considering both the thin reservoir and the thick reservoir. Successfully used this method in Chengbei No. 35 well-zone showed that the many processing steps of the method have its particular characters and demands, the resulted inversion from effective controlling and application of these techniques can play an important role in reservoir description, reserve calculation and drawing up the development plan.

Key words: random modeling, annealing, seismic inversion, variation analysis, constrained model

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Applied study of full-wave acoustic logging. Qin

Xu-ying, Xiao Li-zhi and Chen You-peng. *OGP*, 2004, 39(1): 82~86

In order to improve the applied effects of full-wave acoustic logging data in production, the paper developed the preprocessing techniques of full-wave acoustic logging data including "positioning zero technique" in disordered wave zone, spectrum analysis and application and filtering technique. The method for automatically detecting first break of informational wave by fast specialist-aided computer solved the problem of detecting first break of informational wave in soft formation having weak signal. The paper also analyzed the feature that the gas-bearing formation has different information in full-wave acoustic logging data and ordinary logging data, forming integrative judgement index of natural gas and making the characteristics of gas-bearing formation clearer. The real cases showed that the method has gained good results.

Key words: full-wave acoustic logging, positioning zero technique, specialist-aided technique, gas judgement

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3-D seismic acquisition and processing technique on Shengjinkou west mountain. Luo Zhao, Ni Yudong and Liang Gui-mei. *OGP*, 2004, 39(1): 87~91

The surface and subsurface are very complex on Shengjinkou west mountain, which resulted in poor shooting and receiving conditions, the raw seismic data have lower signal-to-noise ratio and large static correction, causing difficulty for data imaging. In view of above difficulties, in seismic data acquisition, we finely designed geometry and adopted brick pattern geometry (6 lines and 18 shots); according to different surface and lithology distribution, we divided the work area into mountains (foreland zone), farmland and Gobi gravel zone and adopted dynamite source and vibroseis to shot separately; mainly taking deep uphole survey as a basic tool and combing with shallow refraction survey, the precision of model-building of surface has been improved and then the structural model of surface in whole work area has been built up by static correction database. In seismic data processing, taking improvement of signal-to-noise ratio and highlighting the information of lower plate of fault as main objects, the following processing has been well-done; static corrections, prestack noise-removing, wavelet shaping, deconvolution and migration; the velocity scanning has been carried out many times in 3-D migration to build more precious migration velocity fields. The resulted seismic

data from using the set of mountainous 3-D seismic acquisition and processing methods can meet the needs of seismic data interpretation in that region.

Key words: mountainous 3-D seismology, geometry design, shooting parameters, static corrections, migration velocity field

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Integrative layer-labeling technique based on synthetic seismogram. Zhang Yong-hua, Chen Ping, Zhao Yu-qing, Zhu Jun and Liu Jing-yan. *OGP*, 2004, 39(1): 92~96

Seismic layer-labeling is an effective method for connecting geologic, logging and seismic data. The recently-used layer-labeling methods in practice are variety and there are shortcomings if only using each method alone, therefore, the paper presented integrative layer-labeling method of seismic data based on synthetic seismogram. Its concrete steps are as follows: ① building up high precious velocity field; ② taking depth-time transform as a basis, determining the corresponding relation of wave-group characters between synthetic seismogram and seismic traces near borehole and labeling the seismic profile with corresponding geologic horizons; ③ taking the marked bed and major objective events on seismic sections as a mark, repeated correlation of seismic sequence labeled by single-well is carried out according to the sequence of single-well-to-line-to-plane so that the unified corresponding relations between the sequence and the wave-group characters have been formed at all well sites; ④ through synthetic analysis, the corresponding relations between lithologic, electric and physical characters on logging curves and seismic traces near borehole as well as other seismic parameters are created. Application of the method to oil-gas exploration and development in Miyang depression has achieved good geologic results.

Key words: layer labeling, synthetic seismogram, reservoir prediction, sequence stratigraphy, integrative interpretation

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Method for seismic data acquisition in Yellow River mouth area. Liu Cheng-zhai. *OGP*, 2004, 39(1): 97~101

The Yellow River mouth area situated in Shengli Oilfield is key area that has oil-gas resource potential, where the ordinary seismic data

acquisition method is difficult to be success. In view of technical difficulties related to develop the seismic data acquisition in that area, the paper adopted following corresponding strategy: using GPS for survey and positioning; developing water-proofing geophone; completing "drilling-in-case technique", solved the shooting and receiving problems in river shoal, shallow water and deep water; designing the geometry-changed method for crossing the Yellow River, so that a set of data acquisition techniques suitable for Yellow River mouth area has been formed and the quality of seismic data crossing Yellow River channel has been improved, made contribution to increase the reserve and production of the oilfield.

Key words: Yellow River channel, data acquisition, water-proofing geophone, new type's source, geometry-changed design

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3-D seismic-data-based reservoir description technology and methods. **Ran Jian-bin, Li Jian-Xiong, Liu Ya-cun.** *OGP*, 2004, 39(1): 102~112

Reservoir description has been developed from description of single structured attitude of reservoir and prediction of reservoir parameters to building 3-D structural model of reservoir, reservoir model and geologic model of reservoir; from the research of single discipline to integrative research of multi-discipline; from qualitative description to half-quantitative and quantitative prediction; from qualitative appreciation to 3-D reservoir attributes model-building. Laying emphasis on application of following seismic techniques: coherent cube, 3-D visualization, seismic attributes analysis, velocity-changed mapping, well-logging data processing and interpretation, multi-well-constrained inversion and geologic model-building of reservoir, the paper explained that these techniques can solve which kinds of practical geologic problems of oilfield and the trend in the future.

Key words: reservoir parameters, prediction, 3-D seismic data, 3-D reservoir model, reservoir description, integrative research, quantitative prediction

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General use formula in MT tensor impedance. **Tan Han-dong, Wei Wen-bo, Deng Ming and Jin Sheng.** *OGP*, 2004, 39(1): 113~116

It needs to solve how to use the tensor impedance elements calculated from the electrical and magnetic fields that are resulted from numerical modeling when studying 3-D MT numerical modeling. For this reason, the paper theoretically and systematically deduced the general calculation formula of tensor impedance that is suitable for complex telluric model and gave the method for impedance elements calculated from the discrete electrical and magnetic fields that are resulted from numerical modeling. Through deep analysis, we also got direct expression of calculation formula for each general tensor impedance element, showing a clear physical meaning. For example, Z_{xy} represents the ratio between weighted linear stack result of electrical field component produced in x direction and weighted linear stack result of magnetic field component produced in y direction, which deepened the knowledge of tensor impedance.

Key words: MT method, tensor impedance, numerical modeling, electrical field, magnetic field

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Relationship between NMR T_2 cutoff and capillary pressure. **Gao Chu-qiao, He Zong-bin, Wu Hong-shen and Li Mao-wen.** *OGP*, 2004, 39(1): 117~120

The particular advantage of Nuclear Magnetic Resonance (NMR) log is that it can distinguish the irreducible fluid porosity from the free fluid porosity, provided more reliable irreducible brine saturation. T_2 cutoff is the key parameter when using nuclear magnetic resonance logging data to calculate irreducible brine saturation. T_2 cutoff is determined by NMR experiment. Through the NMR experiment of core samples from Yingge-sea Basin, the paper studied the relationship between NMR T_2 cutoff and capillary pressure. The studied results showed that T_2 cutoff decreased exponentially when displacement pressure increased. Therefore, T_2 cutoff is related to the height of gas column. The size of T_2 cutoff needs to be determined by gas column in process of NMR logging data, especially when the reservoir has high irreducible brine saturation, the selection of T_2 cutoff needs to be more careful.

Key words: well logging, NMR, capillary pressure, T_2 cutoff

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