

Acquisition and application of offshore W-VSP in deep gas field in East China Sea basin

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Offshore Walkaway & walkaround VSP(W-VSP) is one of the borehole seismic. Compared with towing cable seismic method, borehole seismic has less absorption and attenuation of high-frequency information because of less propagation paths, so it is an innovation attempt of seismic technology for deep gas fields in East China Sea.

Oil and Gas exploration in East China Sea basin reveals some special geological conditions: deep reservoir, complex structure and reservoir anisotropy which cause many problems in conventional streamer seismic acquisition and processing, such as multiple, low signal-to-noise ratio and low resolution.

The W-VSP test area is fully covered by 3D towing cable seismic data and the local structure is a small faulted anticline trap with nose structure background under the control of basement high. The main target layer is sand-shale interbedded deposited in the braided river delta of Eocene and the drilling shows that the trap is rich in gas in channel reservoir below 4000m.

After selecting the test well, making acquisition simulation design, optimizing the acquisition mode and parameters, W-VSP acquisition was conducted by placing geophone in the borehole and shooting around by seismic vessel. The 2D walkaway was conducted with the same survey line direction as the existing 3D survey to ensure the optimal data quality and matching with the existing data. Shot point range is 6000m for inline and crossline, and 3.0 km and 4.5 km for loop line. Shot interval is 25m. Time sampling rate is 1ms. Record length is 7000ms. The source is 4210in.cu³ (single source) with 4 subarrays and 6m sinking depth.

Good results of field and processing data are obtained from W-VSP, which improves the interpretation accuracy of the structure and reservoir around the wellbore. In the deep layer below 4300m, band width of W-VSP data is 0-80 Hz, main frequency is 45 Hz, far higher than the 25 Hz of the streamer 3D seismic data.

By extracting suitable seismic processing parameters, such as attenuation factor and multiple models, well-driven streamer 3D processing is carried out, and we obtained high quality 3D seismic data with enhanced resolution and signal-to-noise ratio. The test shows that the seismic image can be effectively improved by this technology, which is good for sand tracing and gas reservoir description in offshore deep gas fields.

Well-driven 3D seismic processing mainly uses key technologies to obtain well-driven processing parameters from Z-VSP and W-VSP data, including: (1) true amplitude recovery factor TAR; (2) absorption attenuation factor Q; (3) corridor stack section; (4) anisotropic parameters; (5) time-depth relationship and velocity. Well-driven are mainly from the following aspects. Firstly, wavelet processing, ghost suppression technology and anti-Q filter technology and other offshore wide-band processing technologies are adopted to improve resolution and broaden the frequency band. Secondly, shallow

water multiple suppression, tau-p domain deconvolution, SRME, high-precision radon transform and other techniques are used to suppress various multiples step by step, focusing on the fidelity of de-noising process, to improve the signal-to-noise ratio. Finally, high precision velocity analysis, grid tomography modeling and pre-stack depth migration are applied to improve the imaging accuracy.

According to the analysis of well-driven 3D seismic processing results, due to the enhancement of deep energy and the effective removal of multiples, the results is improved in seismic events, having higher signal-to-noise ratio and better continuity. The sand distribution of the main gas reservoirs in deep layer are consistent with drilling results. Through tracking and interpretation of sand at 4600 m depth, the gas reservoir was revealed as a structural and lithological composite type, with the faulted anticline area of 0.54 km^2 at the high position. However, due to the lateral change of sand, the area of sand inclined stratigraphic trap is 0.38 km^2 . The reserves calculated according to the fine description of this sand are consistent with the developed reserves of gas fields.

Keywords: Walkaway &walkaround VSP, Well-driven 3D seismic processing, true amplitude recovery factor TAR, absorption attenuation factor Q, anisotropic parameters, improved seismic data quality