SUMMARY

Shear wave data from four nine component VSP’s from the Iatan East Howard field, Mitchell County, Texas, have been analysed to determine the nature and extent of shear wave anisotropy. Oil production in this field is from Permian age Clearfork Dolomites. Cores indicate the presence of vertical fractures. Shear-wave splitting was observed on all VSP’s and polarization of the leading split shear wave has been used to infer fracture orientation. The two anisotropic parameters, $qS_1$ polarization and time delay between $qS_1$ and $qS_2$, were measured using two anisotropic estimation techniques. These measurements were confirmed by visual examination of seismograms and particle motions and then used to define an anisotropic model for the rockmass in the vicinity of the VSP. Synthetic seismograms were generated for the model, which gave a good match with observed seismograms and results.

ACQUISITION AND RESULTS

Two wells I-130 and I-227 were used for the VSP acquisition. Data were recorded in I-130 using a 20ft receiver spacing from 3200-2500ft, a 100ft spacing from 2500-1500ft and a 300ft spacing from 1500-300ft. This gave 50 near offset and 36 far offset levels. In well I-227 recording was only between 2700 and 3200ft, with 10 near offset and 11 far offset levels. The fractured Clearfork Dolomites lie between 2300-3200ft. Omnipulse was used as a source of P, SV and SH energy. Two source positions were used, with each shot recorded simultaneously in the two wells. Acquisition geometry is shown in Figure 1. Application of a suitable filtering removed most of the unwanted energy. In the absence of Gyrodata, P-wave arrivals from the far offset source position were used to align the geophones in the horizontal plane. Polarizations of the leading split shear wave and time delays between the $qS_1$ and $qS_2$ arrivals were measured using the DCT and DIT methods described by Zeng and Macbeth (1993). These techniques find an algebraic solution to the recorded shear wave data matrix, or medium response, by direct eigenanalysis and singular value decomposition, respectively. The results for wells I-130 and I-227 near offset VSP’s are shown in Figure 2. Well I-130 shows a build up in time delay from around 1800 ft with a $qS_1$ polarization direction of N170°E. Well I-227 gives a similar result for polarization direction, but time delays are more scattered. Measurements from both far offset source positions indicate a $qS_1$ direction of N60°E. The data matrix was then rotated into the fast and slow directions to confirm the minimization of energy on the off-diagonal elements.

MODELLING

The near offset $qS_1$ polarizations were used to infer a subsurface fracture direction of N170°E. An anisotropic model was derived from the inversion of $qP$, $qS_1$ and $qS_2$ traveltimes. The
model has horizontal layering, with two anisotropic layers of different crack densities. Full waveform modelling with ANISEIS (Taylor 1991), was used to generate synthetic seismograms for propagation through the structure. The estimation techniques were applied to the synthetic data and a comparison of the observed and model polarization is shown in Figure 3, displayed on equal area projections.

REFERENCES


Figure 1. Acquisition geometry of multicomponent VSP experiment.

Figure 2. Results of estimation techniques, (a) qS1 polarization I-130 near, (b) qS1-qS2 delay I-130 near, (c) qS1 polarization I-227 near, (d) qS1-qS2 delay I-227 near.

Figure 3. QS 1 polarizations displayed on equal area projections (a) observed, (b) modelled. Concentric circles mark 10° intervals.