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Estimation of Anisotropy in the Presence of Laterally Heterogeneous Overburden, using Walkaway VSP Data from the Red Sea

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ABSTRACT

Seismic anisotropy introduces imaging problems in surface seismic data processing, which causes lateral mis-positioning of reflectors and depth mis-ties between wells and surface seismic data. Walkaway VSP is one of the effective tools used to estimate anisotropy around wells. For a complex overburden, Grechka and Mateeva (2007) propose an equation for VTI anisotropy parameter estimation, which relates P-wave vertical slowness, q, to the angle between the P-wave's polarization vector, ψ, and the vertical axis.

We present a study in which VTI anisotropy is estimated in salt and clastic formations from VSP data acquired in a Red Sea area – in the presence of heterogeneous overburden – by using P-wave polarization-slowness constrained by borehole data in three different wells. The subjects of this study are: (a) the Burqan Formation, which is a thick succession of deep-marine calcareous mudstones with sand interbeds, (b) the salt body, part of the Mansiyah Formation, with a thickness of approximately 6000 ft in Well #1 and Well #2, and (c) the Ghawas Formation, which is a thick succession of interbedded fine- and coarse-grained siliciclastics and thin beds of anhydrite (Hughes et al., 1999).

Data acquired from three wells in this Red Sea area were used to estimate (a) the anisotropy in the salt of the Mansiyah Formation in Well #1 and Well #2 and (b) the anisotropy of clastic sections in the Ghawas and Burqan formations in Well #3. All three wells were characterized by having laterally-heterogeneous overburdens. Two walkaway VSP lines for Well #1 and Well #2 were designed such that one was oriented parallel to the maximum elongation of the salt body (N145^{o}E and N152^{o}E), and the other oriented perpendicular to maximum elongation of the salt body (N55^{o}E and N62^{o}E). A walkaround VSP was also acquired in Well #1. Well #3 is located closer to the coast in a zone of reefs and small islands and, while three walkaway VSP lines were acquired in this well, only one of the lines was analyzed for this study.

Results of the polarization slowness method indicate that the analyzed salt interval is azimuthally anisotropic. The Burqan and Ghawas formations were found to be also anisotropic with at least VTI symmetry. Migration using our estimated anisotropy parameters reduced the seismic-to-well depth mis-ties and improved the subsurface imaging.