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Surveying a dome structure from a transversely isotropic medium

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Abstract
The impacts of velocity anisotropy on elastic wave propagation are well documented. Many measurement experiments also indicate that the directional dependent velocity is an intrinsic characteristic of an anisotropic medium, i.e. a characteristic that comes automatically with the existence of anisotropy of the medium. Ignoring the velocity anisotropy in the interpretation of reflection data, errors will possibly arise in the calculation of the reflector depth and the interpretation of the subsurface structure.
Phenolite itself is made of interlacing of resin and paper and has been widely adopted to simulate as a transversely isotropic material (TIM) for elastic wave propagation. Focusing on demonstrating the effects of velocity anisotropy on reflection images and viewing into the phenomena of image distortion arisen by the velocity anisotropy, laboratory works were facilitated over two modeling blocks which were cut from a whole piece of Phenolite. One of the TI model has its symmetry axis vertically oriented, which is so called vertical transversely isotropy (VTI); and the other one has its symmetry axis horizontally oriented, named as horizontal transversely isotropy (HTI). AT one side of the modeling blocks, VTI and HTI, a dome-shape concave of the same diameter was machined to serve as a subsurface dome structure.
In reflection exploration, the configuration of subsurface structure is commonly revealed from series of adjacent stacked CMP gather. To figure out the effects velocity anisotropy on imaging the dome structure, both zero offset and non-zero offset data acquisition arrangement were conducted on the flat-side which is opposite to the dome shape structure by the P-type transducer(s). For VTI model, two orthogonal survey lines were run through the model; for HTI model, three survey lines were done, one of the survey line run parallel to the layering, another one run diagonally to the layering and the third one was transverse to the layering. The intersections of the two sets of the survey lines were positioned right corresponding to the apex of the dome structure.
For zero offset shooting, the reflection images which were obtained from the VTI model shown in all of the two profiles show a pretty high in similarity to confirm the transversely isotropic properties of the Phenolite. While the images were collected from the HTI model, it can be noticed the reflections originated from the apex of the dome structure show themselves up at almost the same arrival times. However, as the surveying positions were moved away from the apex of the machined dome the variation in images become obvious.
For non-zero offset shooting, the interval between transducers is set to be 1.5 cm to collect constant offset images. In this case, the images collected from the VTI model still show a high similarity to each other. While comparing to those collect from zero offset arrangement, the images become boarder to reflect the velocity anisotropy. As the reflection experiments go to HTI model, the images not just become boarder but the configurations vary with each other. Besides, the reflections observed from the apex of dome arrived with different travel times.
Results, images collected from both VTI and HTI dome-shape model, clearly demonstrate the effects of velocity anisotropy in reflection seismology. Our work not just confirmed the conjecture of the phenomena of image distortion due to the existence of velocity anisotropy but also stresses the importance of taking velocity anisotropy into account when processing seismic data in the anisotropic media.