The 9th International Conference on Applied Geophysics
(GEOPHYSICS CHIANG MAI 2023)
Chiang Mai, Thailand

Ray Tracing Inversion: VSP/Checkshot Time-Depth Correction in Deviated Wells

Tharit Tangkijwanichakul*, Paveen Suthisripok, Tosapol Tongpet, Achiraya Soodsai and Non Prapasanobon

PTT Exploration and Production Public Company Limited, Bangkok, 10900, Thailand
* Corresponding author. E-mail address: tharitt@pttep.com

Abstract

Velocity profile from vertical seismic profile (VSP) or checkshot has been regarded as a tool for high-integrity time-depth conversion. The honor is taken as given and rarely questioned. However, once we go down the technical rabbit hole, the story is not so simple. When the operation is logically complex, the velocity profile is acquired by placing the source near the rig, the velocity profile, expressed in time-depth relation, from this configuration will go through a simple arithmetic correction by projecting rays to vertical axis - called cosine correction. This simple correction has its inherent assumption of the seismic ray being straight all the way from source to receivers. This cosine correction is deemed insufficient in deviated wells because under this scenario the seismic ray will bend continuously as it travels through geological layers. This effect will exhibit itself by the ray being curved ("ray bending effect") and can only be properly handled via explicit numerical ray tracing.

We build the application, completely developed in-house using Python, to correct such effects described above. The proposed program is composed of three components: ray tracing, non-linear inversion, and walk-above simulation. The non-linear inversion iteratively updates the velocity profile until the ray-traced travel-time residual is minimized. Subsequently, this velocity profile is used in the walk-above simulation to get the ideal time-depth relation for the purpose of time-depth conversion.

We successfully demonstrate the effectiveness and performance of the algorithms with complex synthetic velocity layers and actual field data from offshore Myanmar where rig-source VSP operation is usually preferred. In this case, up to 35 m of depth prediction error embedded in the ray-bending effect is eliminated.

The program solves the limitation of VSP correction, pushing technical boundaries by eliminating the inherent depth (or time) shift embedded in the time-depth relation caused by the ray bending effect which cannot be handled previously through cosine correction. This will eventually lead to less depth prediction error from using properly corrected VSP/checkshot data.

Keywords: VSP, checkshot, inversion, tomography, time-depth conversion