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Subsalt Velocity Estimation Using Wave-Equation Tomography with Surface Offset Gathers

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ABSTRACT

It's often very challenging to estimate subsalt velocities due to poor and uneven illumination in the subsalt area. The challenges are mainly twofold. Firstly, it's very difficult to extract reliable residual moveout (RMO) information in pre-stack common image gathers (CIGs). Secondly, the seismic wave path is very complex and needs an accurate propagator to generate the sensitivity kernel for velocity estimation. To extract RMO information, there are two major types of CIGs used in the industry: surface offset gathers (SOGs) and angle domain CIGs(ADCIGs). ADCIGs are less prone to geometric artifacts when multi-pathing occurs. The maximum incident angle gradually decreases with depth to small values, which makes RMO extraction hard in subsalt areas, while SOGs always contain the entire offset range and provide more reliable RMO information. The sensitivity kernel can be built by ray tracing methods and wave equation (WE) tomographic operators. In subsalt areas, ray tracing cannot handle the large velocity contrast between salt and surrounding sediments, while wave-equation tomography can better construct the wave path transmitted through the subsalt area. Previous work mainly concentrated on SOG extraction from WE migration and used the RMO information with conventional ray tomography (Yang et al., 2015). Recently, Fleury et al. (2014) used SOGs from attribute migration in WE tomography while Zhang et al. (2014) used the conventional offset group method. All of these methods have either accuracy or efficiency problems. In this work, we apply plane-wave encoding to decrease the computational cost without loss of accuracy. Stork et al. (2002) suggested using plane wave encoding to generate SOGs, but they did not use it in WE tomography. We found that it's possible to improve the efficiency further by optimal selection of plane-wave values for different offsets. We apply SOG WE tomography to build subsalt velocity models. To overcome the main disadvantage of the high computational cost, plane-wave encoding is optimized to improve the efficiency. Theoretical moveout analysis and numerical tests demonstrate the equivalence of plane-wave SOGs and standard SOGs. We also derive the formulas for RMO-based WE tomography and applied plane-wave SOG to velocity estimation. Preliminary comparisons between SOG-based WE tomography and plane-wave-index-gather-based WE tomography show that our method can provide more reliable velocity update information in subsalt areas.